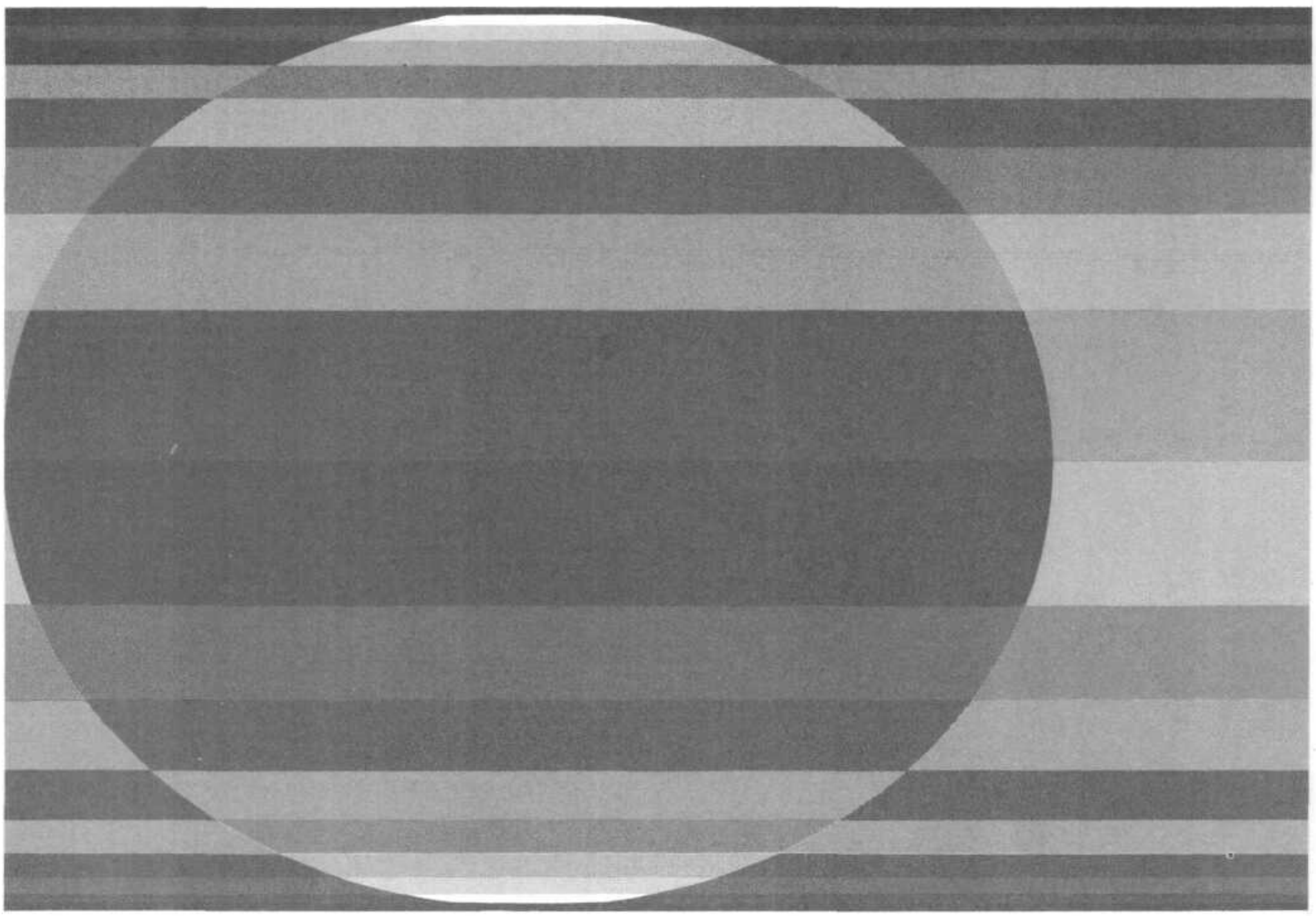
BACKGROUND PAPER

Retaliatory Issues for the U.S. Strategic Nuclear Forces

June 1978



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RETALIATORY ISSUES FOR THE U.S. STRATEGIC NUCLEAR FORCES

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PREFACE

The most important role for U.S. strategic nuclear forces is to deter Soviet nuclear attacks by the threat of retaliation. Because of increased vulnerability of U.S. land-based missiles and the improved Soviet civil defense program, questions have been raised concerning the ability of U.S. forces to retaliate effectively in the future against the Soviet Union. Proposals to develop several new weapon systems to respond to these threats have been presented to the Congress.

This background paper, prepared at the request of the Senate Budget Committee, discusses the capabilities of both current and possible future strategic nuclear forces to destroy industrial and military targets in the Soviet Union after absorbing a massive Soviet surprise attack. Together with a companion paper, Counterforce Issues for the U.S. Strategic Nuclear Forces, this study supports a forthcoming budget issue paper on strategic nuclear forces for fiscal year 1979. In accordance with CBO's mandate to provide objective analysis, this paper offers no recommendations.

This paper was prepared by John B. Shewmaker and Mary R. Tietz of the National Security and International Affairs Division of the Congressional Budget Office, under the supervision of James R. Blaker, David S.C. Chu, and John E. Koehler. Computer programming was done by James Reierson of the Computer Sciences Corporation and Virginia G. France of CBO. Cost estimates were provided by Edward A. Swoboda of CBO's Budget Analysis Division. The authors wish to acknowledge the assistance of Nancy J. Swope, Robert R. Soule, and Carl R. Neu. Patricia H. Johnston edited the manuscript, and Connie S. Leonard prepared it for publication.

Alice M. Rivlin
Director

June 1978

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SUMMARY

One of the most important roles for U.S. strategic nuclear forces is the deterrence of Soviet nuclear attacks by the threat of retaliation. This paper focuses on this retaliatory role: that is, the capability of U.S. nuclear forces to destroy people, industrial plants, and military forces in the Soviet Union in retaliation for a Soviet nuclear attack against the United States.

At present, the United States can effect great destruction on the Soviet Union in a second-strike attack. CBO's analysis indicates that, even after receiving a massive, surprise Soviet nuclear attack aimed at destroying U.S. nuclear forces, at least 120 U.S. bombers, 17 Poseidon submarines, and 700 land-based, intercontinental ballistic missiles (ICBMs) would survive. This means that the United States would have about 5,000 nuclear weapons remaining after absorbing a Soviet first strike. Assuming about 1,000 of these weapons were held in reserve and the remainder were launched in retaliation against the Soviet Union, enough weapons would be expected to hit their intended targets to destroy 80 percent of the Soviet industrial target base and 90 percent of military facilities other than missile silos. 1/ This retaliation could kill between 20 million and 95 million people in the Soviet Union, depending on the effectiveness of Soviet civil defense efforts.

Each component of the present U.S. strategic nuclear forces--bombers, ICBMs, and submarine-launched ballistic missiles (SLBMs) --has great, independent, destructive power. Each has the capability, independently, of destroying 75 percent or more

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1/ The Soviet industrial target base does not include all of Soviet industry. Rather, it is a target base that includes those facilities that have been estimated to be important targets for a major retaliatory strike. "Military facilities other than silos" include Soviet army, air force, and naval installations as well as theater nuclear weapons and all nuclear weapon storage sites--in other words, all military targets other than ICBM silos and their launch control facilities.

of the Soviet industrial target base even after absorbing a massive Soviet nuclear attack. (This assumes that all ICBM, bomber, or SLBM weapons are allocated solely to industry and none to military targets.) Together, the three components of the strategic forces provide important hedges against unexpected Soviet technological breakthroughs. If, for example, the Soviets were capable of destroying all U.S ICBMs in a surprise nuclear attack--a capability that few believe the Soviet Union possesses--those bomber and submarine forces that would be expected to survive the attack could still be expected to destroy about 85 percent of the Soviet industrial target base if no weapons were allocated to military targets or held in reserve. Even if the Soviets destroyed all of the U.S. nuclear weapons launched by ICBMs and submarine-launched missiles, U.S. bombers could still destroy about 75 percent of the Soviet industrial base. Alternatively, if the Soviets developed an air defense system that prevented U.S. bombers from reaching their targets, the surviving U.S. ICBM and submarine forces could still destroy some 90 percent of the Soviet industrial target base.

Soviet civil defense efforts might erode the destructive potential of current U.S. forces. With no Soviet civil defense measures, for example, a U.S. retaliatory strike could be expected to kill about 95 million people, slightly over one-third of the total population. A moderately effective program might reduce fatalities to about 40 million; a more effective program, which could evacuate 75 percent of the people in the cities to the countryside and place nearly all the people in shelters, might reduce fatalities to about 20 million people, less than 10 percent of the population.

There is, however, a tradeoff between Soviet civil defense programs and the capability of the Soviet Union to launch a surprise attack; that is, it is unlikely that the Soviet Union could implement an effective civil defense program without alerting the United States to a pending attack. The higher the U.S. alert posture, the greater the number of U.S. weapons remaining after a Soviet first strike--weapons that could, with careful retargeting and retention of forces in reserve, counteract Soviet civil defense efforts. An effective Soviet evacuation plan would, for example, take at least three days to accomplish. Since an extensive evacuation could not be hidden from the United States, the United States would almost certainly place its own nuclear forces on alert. If the Soviet Union launched a first strike against U.S. nuclear forces that were on alert, about 2,500 more weapons would survive than if an attack had been targeted

against U.S. nuclear forces in their normal, day-to-day alert status. These remaining weapons would be sufficient both to destroy nearly all Soviet cities and military facilities and to retain about 4,000 Poseidon warheads in reserve. These reserve weapons, in turn, could be used to continue the conflict. 2/

If the Soviet Union were to harden extensively its industrial machinery by the use of sandbags or by other means in preparation for nuclear war, this work would also take time and would be unlikely to escape the detection of the United States. The warning given by these efforts would allow the United States to place its bomber force on alert. Given a high alert status, the surviving U.S. bomber force (with its larger-yield weapons) would be capable of destroying a higher percentage of hardened industry than would be possible if the United States had not been alerted to an impending attack by Soviet industrial hardening efforts.

SOVIET CAPABILITIES AND TARGET GROWTH IN THE FUTURE

The future destructive potential of the U.S. strategic nuclear forces will depend in large part on what improvements the Soviet Union makes to its own forces over the next decades. As the Soviet Union increases the number of its missile warheads (by replacing single warheads on ICBMs with multiple independently targeted reentry vehicles, or MIRVs) and improves their accuracy, the U.S. Minuteman ICBMs will become more vulnerable to attack. Soviet industrial growth could increase the number of U.S. weapons that would be required to achieve about the same percentage of destruction as is now possible. Finally, it is possible that Soviet technological breakthroughs in air or ballistic missile defense or in antisubmarine warfare could occur in the future. Soviet technological breakthroughs of the sort that would be necessary to neutralize various components of the U.S. nuclear forces could occur, but they seem unlikely on the basis of what is now known or projected. Further, there is normally some time between a breakthough and the deployment of weapons that make use of a new technology.

2/ To carry out this strategy, the United States would require survivable reconnaissance assets to identify targets, a command center to designate targets to the surviving forces, and some means of communication.

To simulate nuclear exchanges between the United States and the Soviet Union for the mid-to-late 1980s and the 1990s, a reasonable set of assumptions must be selected to deal with these uncertainties. A baseline set of U.S. forces, described below as a finite deterrence force, was constructed and its capabilities were computed under the following assumptions:

- o The number of U.S. Minuteman missiles that could survive a surprise Soviet counterforce attack will decrease from about 700 currently to less than 500 in the early-to-mid 1980s, and to fewer than 100 by the 1990s, because of the improved accuracy of Soviet ICBMs.

- o The Soviet Union will not achieve a technological breakthrough in air defense or antisubmarine warfare sufficient to offset currently programmed or future improvements in the capabilities of U.S. weapons. Specifically, through the 1990s, four out of five surviving bombers will penetrate Soviet air defenses, and all submarines at sea will survive a Soviet first strike through the 1990s.

- o The growth of Soviet industrial facilities will not increase requirements for additional U.S. weapons to destroy them by more than 40 percent by the 1990s.

- o The number of Soviet military facilities against which U.S. nuclear strikes might be targeted will not increase in the future.

- o Half of the Soviet industrial base will be "hardened" in such a way as to be protected from destruction incurred by a building collapse.

U.S. RETALIATORY CAPABILITIES IN THE FUTURE

Finite Deterrence

Given the assumptions, one way in which the Congress could maintain the current level of retaliatory capability over the next 10 to 15 years would be by developing a finite deterrence force. This option would improve current U.S. strategic nuclear forces by deploying cruise missiles on B-52 bombers and Trident I missiles in submarines. It would build toward a force structure composed of 330 B-52 bombers (half of which would be armed with cruise missiles), 60 FB-111s, 20 Trident submarines with Trident I

missiles, and 1,000 land-based Minuteman missiles. 3/ The finite deterrence force would cost about $120 billion (in fiscal year 1979 dollars) between fiscal year 1979 and the year 2000 for investment and for operation and maintenance.

Based on the assumptions regarding Soviet improvements over the next two decades, this finite deterrence force could probably:

- Emerge from a no-warning, massive Soviet first strike with operable U.S. forces of some 120 bombers, 16 submarines, and 90 Minuteman missiles; and

- In retaliation, destroy 80 to 90 percent of the Soviet industrial target base and military targets; while

- Holding over 500 Trident I weapons in reserve to continue the nuclear conflict, if required after the first exchange, in addition to 500 Trident I weapons as a hedge against target growth.

In addition, such a finite deterrence force would provide hedges against a Soviet technological breakthrough. CBO's calculations indicate that the U.S. force would be capable of destroying 75 percent of the industrial target base in the Soviet Union in spite of a major breakthrough in air defense, antisubmarine warfare, or antiballistic missile defense. The following table summarizes the retaliatory capabilities of the finite deterrence force and its hedge capabilities over the next 15 years.

A great deal of uncertainty is associated with calculations of retaliatory capabilities. And, even if the calculations outlined above were roughly accurate, two major questions remain:

3/ The projected U.S. forces for finite deterrence assume that the first Trident submarine would enter the U.S. fleet in 1980 and that succeeding units would enter the fleet six years after authorization by the Congress. To the extent that delays in the Trident program are not recouped by an increase in the production rate to two submarines a year in the 1980s, the capabilities of the finite deterrence force are somewhat overstated.

RETALIATORY CAPABILITIES OF THE FINITE DETERRENCE FORCE: PERCENT DAMAGE TO SOVIET TARGET BASE

	Current	Mid-1980s	1990s
Total Force a/			
Industrial target base	80	80	80
Military targets	90	90	90
Capability to Hedge Against Soviet Developments b/			
Against ABM: No ballistic missile warheads, only bombers attack			
Industrial target base only	75	80-85	75-85
Industrial and military targets	35	55-60	50-60
Against ICBM vulnerability: No surviving ICBMs, only bombers and submarines attack			
Industrial target base only	85	90	90
Industrial and military targets	65	80-85	75-85
Against ASW: No surviving submarines, only bombers and ICBMs attack			
Industrial target base only	90	85-90	80-85
Industrial and military targets	70	70-75	55-65
Against air defense: No bomber weapons, only submarines and ICBMs attack			
Industrial target base only	90	90	85-90
Industrial and military targets	75	75-80	60-70

a/ Weapons expected to survive a first strike are allocated to achieve over 80 percent damage to the industrial target base, assuming half were hardened to 30 pounds per square inch (psi). One thousand submarine warheads are held in reserve. The remainder of the weapons are allocated to military targets other than silos (at least one ballistic missile weapon is allocated to each military airfield and 100 SRAMs are allocated to air defense sites). No Soviet ICBM silos are included in the military target base.

b/ All surviving weapons of forces indicated are allocated; no weapons are held in reserve. For the mid-1980s column, the low end of the range assumes a 20 percent growth in industrial targets; the high end assumes no growth. For the 1990s column, the low end of the range assumes a 40 percent growth in industrial targets; the high end assumes no growth.

Would Soviet decisionmakers make the same assessment as U.S. leaders of the ultimate results of a nuclear exchange? Whatever their assessment, would it deter them from initiating an exchange?

There are no clear answers to these questions. Development of a finite deterrence force would be a shift away from the concept of three surviving force components because the current U.S. Minuteman force is assumed to be vulnerable to Soviet nuclear attack by the 1990s. A finite deterrence force would be an indication that the United States did not intend to match Soviet capabilities to destroy land-based missiles.

A finite deterrence force would appeal to those who believe that the ability to devastate the Soviet Unon in response to a nuclear attack on the United States is an adequate deterrent and who see little rationale for the procurement of additional nuclear forces. On the other hand, criteria other than retaliatory capability must be considered in determining U.S. strategic force posture, such as how the strategic balance may be perceived by allies and other nations.

Maintain a Survivable Land-Based Missile Force

Although the factors discussed above make it seem improbable, a finite deterrence force might entail some risk to U.S. retaliatory capability in the fuure. If the increasing vulnerability of U.S. ICBM silos were paralleled by the emergence of a very effective Soviet civil defense program as well as the development of an effective Soviet air defense, the capabilities of the finite deterrence force would be eroded--particularly before Trident I enters the force in large numbers. It is most unlikely that all these events would occur simultaneously. But if they did take place over the next decade, they would reduce the level of destruction the United States could inflict on the Soviet Union, while still retaining a large reserve of weapons for possible use after a retaliatory strike.

The Congress could seek to counteract what seems the most probable of future changes--the increasing vulnerability of the Minuteman force--by supporting the development and deployment of a less vulnerable land-based system. The procurement of 300 MX missiles, for example, would maintain a land-based component of the U.S. nuclear arensal that would be significantly less

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vulnerable to a Soviet attack than the current Minuteman force. 4/ This would increase the hedges against Soviet breakthroughs in antisubmarine warfare and air defense. As measured by the ability to destroy both industrial and military targets, the addition of 300 MX missiles would result in 75 to 85 percent damage in case of a breakthrough by the Soviets in both areas. But this kind of insurance would be expensive. It would add some $30 billion (in fiscal year 1979 dollars) to the costs of the strategic forces, for a total cost of about $150 billion over the 22-year period between fiscal years 1979 and 2000.

Other Options

Other options to strengthen the strategic forces would include increasing the capability of both the submarine force and the bomber force. Additions to both forces would be required to increase the capability to hedge against a Soviet breakthrough in antisubmarine warfare and air defense. A forthcoming budget issue paper on U.S. strategic nuclear forces will discuss these alternatives as well as force requirements for a U.S. capability to destroy Soviet silos.

4/ Current plans call for mobile basing for MX missiles. The missiles would be moved either within underground trenches or among protective above-ground shelters.

CHAPTER I. INTRODUCTION

The military forces of the United States--both strategic nuclear and general purpose--provide the nation with the capability to threaten, attack, or resist other nations. 1/ Because U.S. forces are large and diverse, the range of options they offer is broad. The perception that the United States has capable forces that can be used in many areas and circumstances serves to deter adversaries and reassure allies, thereby helping to maintain the security of the nation and achieve some valuable international political objectives.

Strategic nuclear forces play various roles in shaping perceptions, providing deterrence by threats of retaliation, and destroying targets in wartime. This paper focuses on the retaliatory role of strategic nuclear forces--that is, how they deter Soviet nuclear attacks by providing the United States with the capability to destroy people, industrial targets, and military forces in the Soviet Union, even after U.S. forces have themselves been attacked by a Soviet "first strike."

There is no way to determine exactly how much damage the United States should be able to inflict on the Soviet Union in

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1/ U.S. military forces are usually divided into two broad categories: strategic nuclear and general purpose. The strategic nuclear forces include intercontinental ballistic missiles (ICBMs), submarine-launched ballistic missiles (SLBMs), B-52 and FB-111 bombers, air defense missiles and interceptors defending North America, and the associated units and facilities required to control and support these forces. (See the Glossary for descriptions of weapons systems discussed in this paper.) The remaining U.S. air, sea, and ground forces are termed "general purpose forces." The term "strategic nuclear forces" is used rather than "nuclear forces" because the general purpose forces include a number of shorter-range systems--such as nuclear artillery, nuclear-capable fighter/attack aircraft, and short-range missiles--that are capable of delivering nuclear weapons.

order to deter a nuclear attack. That depends on how large the stakes in some future conflict might be perceived to be, the costs both sides might be willing to bear, and the losses they see each other as willing to risk. Yet, to judge the adequacy of the U.S. nuclear arsenal, some criterion of damage is required.

Several such criteria have been suggested. In the late 1960s, then Secretary of Defense Robert McNamara identified the capability to destroy large portions of Soviet industry and population as a useful measure of the deterrent value of the U.S. strategic nuclear forces. 2/ More recently, Secretary of Defense Brown identified the capacity to destroy a minimum of 200 major Soviet cities as the level necessary to deter a Soviet nuclear attack. 3/ Current official doctrine identifies the capability to destroy "targets critical to enemy post-war power and recovery" (which include military forces and industry) as a measure of retaliatory strength. 4/

This paper calculates the destructive potential of the U.S. strategic nuclear forces that would be expected to survive a massive Soviet attack on the U.S. forces that is launched without warning. The extent of destruction to the Soviet industrial and military target base that could be achieved by the surviving

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2/ For example, in the annual Defense Department report for fiscal year 1969, Secretary of Defense McNamara said: "I would judge that a capability on our part to destroy, say, one-fifth of her population and one-half to three-quarters of her industrial capacity would serve as an effective deterrent. Such a level of destruction would certainly represent intolerable punishment to any 20th century industrial nation." (See Department of Defense, Annual Report, Fiscal Year 1969, p. 50.)

3/ Department of Defense, Annual Report, Fiscal Year 1979, p. 55.

4/ Fiscal Year 1978 Authorization for Military Procurement, Research and Development, and Active Duty, Selected Reserve, and Civilian Personnel Strengths, Hearings before the Senate Committee on Armed Services, 95:1 (January-February 1977), Part 2, pp. 838-839.

U.S. forces is computed, as well as the number of Soviet fatalities in such a nuclear exchange. 5/

WHY MEASURE RETALIATORY EFFECTIVENESS?

There are several reasons why it is important to try to calculate whether the United States has now and will continue to have "enough" strategic nuclear destructive power to deter the Soviet Union from launching a nuclear attack. The U.S. ICBM force will become increasingly vulnerable as new, more accurate ICBMs enter the Soviet strategic forces. Therefore, fewer weapons will be available for a U.S. retaliatory strike. Civil defense programs and efforts to protect Soviet industry from the effects of nuclear war are improving. Meanwhile, recent Administration decisions, such as those to cancel procurement of the B-1 bomber and to introduce the cruise missile into the U.S. strategic nuclear weapons inventory, are changing U.S. capabilities.

Thus, the Congress will make decisions on a number of important issues over the next several years that will involve judgments about the adequacy of U.S. nuclear forces to deter a Soviet attack. These judgments require answers to the following questions:

- How many U.S. weapons are required to inflict significant damage to the Soviet industrial target base in a second, retaliatory strike?
- How many additional weapons are required to attain a capability to attack Soviet general purpose forces?
- What effect do Soviet civil defense preparations have on the U.S. retaliatory capability?

The Congress will implicitly answer these questions when it determines the pace of development and procurement of a new

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5/ The Soviet population is not currently targeted in Department of Defense plans for the use of U.S. strategic nuclear forces. Yet in an actual nuclear exchange, millions of people would be killed, and estimates of the number of people killed in a postulated nuclear strike have commonly been used as a measure of destructive potential.

generation of strategic nuclear weapons--MX mobile ICBMs, Trident nuclear submarines, Trident missiles, cruise missiles, and cruise-missile carriers. In resolving these issues, the Congress will be defining the strategic nuclear relationship between the United States and the Soviet Union for the rest of this century.

The U.S. nuclear arsenal consists of thousands of nuclear weapons, and there are thousands of possible targets in the Soviet Union. In order to assess the capability of U.S. forces to retaliate effectively against the Soviet Union, the SNAPPER Damage Assessment Model developed for the Air Force by the Rand Corporation was used to calculate the results displayed in this paper. The computer model, postulated targets, and major assumptions are discussed in Appendix B. 6/

Chapter II describes and assesses the current retaliatory capabilities of the United States and assesses the future capabilities of a baseline force. Chapter III addresses the potential impact of Soviet civil defense measures on these capabilities. The paper concludes with assessments of various courses the Congress could take, from supporting little, if any, change to current U.S. strategic nuclear forces to providing for the introduction of a new generation of weapons to those forces.

6/ The model does not account for several limitations in weapons targeting: there are no range limitations on offensive weapons, no computation of "footprints" for multiple-warhead missiles (a Poseidon missile, for example, must have 10 targets within the area in which it can disperse its warheads), and no restrictions on bomber targets. (In reality, a bomber must have a programmed track and must attack targets on that track.) The net effect is that the model moderately overstates capabilities.

CHAPTER II. RETALIATORY CAPABILITIES

The ability of the U.S. strategic nuclear forces to destroy Soviet industrial and military targets is generally used as a measure of retaliatory capability. By this measure, the U.S. arsenal is quite potent.

U.S. strategic nuclear forces consist of three components: land-based intercontinental ballistic missiles (ICBMs), long-range bombers, and submarine-launched ballistic missiles (SLBMs). The characteristics of the current arsenal are displayed in Table 1. Even after absorbing a massive Soviet first strike while U.S. forces were in their normal, day-to-day alert status:

- o Each component of the arsenal could, by itself, destroy at least 75 percent of the industrial target base in the Soviet Union; 1/

- o Two of the three components could destroy at least 65 percent of the Soviet industrial target base and of the military targets other than ICBM silos; 2/ and

- o All three components could destroy over 80 percent of the industrial target base and general purpose force targets and governmental centers, while keeping 1,000 weapons in reserve to continue the conflict if required. Current U.S. weapons systems have little capability to destroy Soviet ICBM silos.

1/ The industrial target base used for CBO calculations does not include all Soviet industry. Instead, the base is an estimate of the Soviet industrial targets that the United States would want to destroy in a major retaliatory strike.

2/ Military targets other than silos, as defined in this paper, include Soviet army, air force, and naval installations as well as theater nuclear weapons and all nuclear weapon storage sites--in other words, all types of military targets other than ICBM silos and their launch control facilities.

TABLE 1. ESTIMATED CHARACTERISTICS OF CURRENT U.S. STRATEGIC NUCLEAR FORCES a/

Launcher	Number	Warheads per Vehicle	Total Warheads	Yield in Megatons b/	Reliability c/	Circular Error Probable d/
ICBMs						
Minuteman II	450	1	450	1.00	0.80	1,800 ft.
Minuteman III	550	3	1,650	0.17	0.80	700 ft.
Titan	54	1	54	9.00	0.75	3,000 ft.
Total ICBMs	1,054		2,154			
Submarine Missiles						
Polaris	160	1	160	0.60	0.80	3,000 ft.
Poseidon	496	10	4,960	0.04	0.80	1,500 ft.
Total SLBMs	656		5,120			
Bombers						
B-52D	75	4 Bombs	300	1.00	0.76	1,000 ft.
B-52G/H	255	4 SRAMs/4 Bombs	2,040	0.20/1.00	0.70/0.76	1,200/1,000 ft.
FB-111	60	2 SRAMs/2 Bombs	240	0.20/1.00	0.70/0.76	1,200/1,000 ft.
Total Bombers	390		2,580			
Grand Total	2,100		9,854			

SOURCES: There is fairly wide agreement among various unclassified estimates of U.S. nuclear forces. For ICBM and SLBM figures, see Hon. Thomas J. Downey, "How to Avoid Monad and Disaster," Foreign Policy (Fall 1976), pp. 178-179; Statement of the Honorable Robert L. Leggett, in Vladivostok Accord: Implications to U.S. Security, Arms Control, and World Peace, Hearings before the Subcommittee on International Security, House Committee on International Relations, 94:1 (June-July 1975), pp. 8-14; and Kosta Tsipis, "The Accuracy of Strategic Missiles," Scientific American (July 1975), p. 190. Minuteman III CEP of 700 ft. (see "U.S. Plans 'Cold-Launch' ICBMs," Aviation Week and Space Technology (February 4, 1974), p. 14) assumes the more accurate MK-12A warhead has not yet been deployed. For bomber estimates, see Archie L. Wood, "Modernizing the Strategic Bomber Force Without Really Trying--A Case Against the B-1," International Security (Fall 1976) and Alton H. Quanbeck and Archie L. Wood, Modernizing the Strategic Bomber Force (Washington, D.C.: The Brookings Institution, 1976), p. 36.

a/ See the Glossary for descriptions of weapons systems.

b/ A megaton is a measure of the destructive power of a nuclear weapon and is equivalent to 1,000,000 tons of TNT.

c/ Reliability is the probability that a weapon will operate as designed. For bomber weapons, the probability of penetrating Soviet air defenses is also included.

d/ CEP is a measure of the delivery accuracy of a weapon system. It is tne radius of a circle within which half the weapons aimed at a target are expected to fall.

The amount of destruction the United States would be able to inflict on the Soviet Union in a retaliatory strike in the future depends, of course, on developments in both nations' strategic forces over the next decade. Improvements in the accuracy and destructive power of Soviet ICBMs could, for example, mean that fewer U.S. weapons would be left to retaliate against the Soviet Union after a Soviet first strike. Soviet improvements in air defenses or in civil defense measures could also erode the destructive potential of U.S. nuclear forces. Industrial expansion could increase the number of targets and, therefore, the number of weapons required to destroy those targets. In contrast, improvements in U.S. forces over the next decade might more than compensate for changes in the forces or defenses of the Soviet Union.

In short, predictions about the future strategic nuclear relationship between the United States and the Soviet Union require a number of assumptions. A systematic assessment requires the construction of a baseline U.S. force structure, the effectiveness of which can be judged against projections of Soviet improvements in the future. To do so, CBO has constructed what may be termed a "finite deterrence" force for the United States, the components of which for the mid-1980s and 1990s are portrayed in Tables 2 and 3. The finite deterrence force represents a continuation of strategic nuclear programs currently underway.

As Table 3 shows, the U.S. strategic nuclear forces in the 1990s would differ from today's forces (see Table 1) primarily through the introduction of cruise missiles and Trident submarines. It postulates the same ICBM force as currently exists, a decline in the total number of delivery systems (as the more capable Trident submarine replaces the older Polaris and Poseidon submarines), but an increase in total warheads. 3/

This, then, was the baseline force used in simulations of U.S. retaliatory strikes against the Soviet Union. In estimating the retaliatory capabilities of U.S. forces, there are several key questions:

3/ The finite deterrence force does not include weapons systems like the MX or Trident II. It is a baseline projection against which the addition of these systems can be compared (see Chapter IV).

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TABLE 2. ESTIMATED CHARACTERISTICS OF U.S. STRATEGIC NUCLEAR FORCES IN THE MID-1980s: FINITE DETERRENCE FORCE STRUCTURE a/

Launcher	Number	Warheads per Vehicle	Total Warheads	Yield in Megatons b/	Reliability c/	Circular Error Probable d/
ICBMs						
Minuteman II	450	1	450	1.00	0.80	1,800 ft.
Minuteman III	550	3	1,650	0.17	0.80	700 ft.
Titan	54	1	54	9.00	0.75	3,000 ft.
Total ICBMs	1,054		2,154			
Submarine Missiles						
Poseidon	336	10	3,360	0.04	0.80	1,500 ft.
Poseidon C-4	160	8	1,280	0.10	0.80	1,500 ft.
Trident I	240	8	1,920	0.10	0.80	1,500 ft.
Total SLBMs	736		6,560			
Bombers						
B-52G/H	165	6 SRAMs/4 bombs	1,650	0.20/1.00	0.70/0.76	1,200/1,000 ft.
B-52CM	165	20 cruise missiles	3,300	0.20	0.70	300 ft.
FB-111	60	2 SRAMs/2 bombs	240	0.20/1.00	0.70/0.76	1,200/1,000 ft.
Total Bombers	390		5,190			
Grand Total	2,180		13,904			

SOURCES: Trident I missile estimates from "New Propellant Evaluated for Trident Second Stage," *Aviation Week and Space Technology* (October 13, 1975), p. 15. Cruise missile yield from "ICBM Guidance Curbs Alarm Planners," *Aviation Week and Space Technology* (July 11, 1977), p. 17. Cruise missile CEP from Kosta Tsipis, "Cruise Missiles," *Scientific American* (February 1977), p. 29. Cruise missiles assumed carried by 75 B-52Ds and 90 B-52Gs.

a/ See the Glossary for descriptions of weapons systems.

b/ A megaton is a measure of the destructive power of a nuclear weapon and is equivalent to 1,000,000 tons of TNT.

c/ Reliability is the probability that a weapon will operate as designed. For bomber weapons, the probability of penetrating Soviet air defenses is also included.

d/ CEP is a measure of the delivery accuracy of a weapon system. It is the radius of a circle within which half the weapons aimed at a target are expected to fall.

TABLE 3. ESTIMATED CHARACTERISTICS OF U.S. STRATEGIC NUCLEAR FORCES IN THE 1990s: FINITE DETERRENCE FORCE STRUCTURE a/

Launcher	Number	Warheads per Vehicle	Total Warheads	Yield in Megatons b/	Reliability c/	Circular Error Probable d/
ICBMs						
Minuteman II	450	1	450	1.00	0.80	1,800 ft.
Minuteman III	550	3	1,650	0.17	0.80	700 ft.
Titan	54	1	54	9.00	0.75	3,000 ft.
Total ICBMs	1,054		2,154			
Submarine Missiles						
Poseidon C-4	80	8	640	0.10	0.80	1,500 ft.
Trident I	480	8	3,840	0.10	0.80	1,500 ft.
Total SLBMs	560		4,480			
Bombers						
B-52G/H	165	6 SRAMs/4 bombs	1,650	0.20/1.00	0.70/0.76	1,200/1,000 ft.
B-52CM	165	20 cruise missiles	3,300	0.20	0.70	300 ft.
FB-111	60	2 SRAMs/2 bombs	240	0.20/1.00	0.70/0.76	1,200/1,000 ft.
Total Bombers	390		5,190			
Grand Total	2,004		11,824			

SOURCES: Trident I missile estimates from "New Propellant Evaluated for Trident Second Stage," Aviation Week and Space Technology (October 13, 1975), p. 15. Cruise missile yield from "ICBM Guidance Curb Alarms Planners," Aviation Week and Space Technology (July 11, 1977), p. 17. Cruise missile CEP from Kosta Tsipis, "Cruise Missiles," Scientific American (February 1977), p. 29. Cruise missiles assumed carried by 75 B-52Ds and 90 B-52Gs.

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c/ Reliability is the probability that a weapon will operate as designed. For bomber weapons, the probability of penetrating Soviet air defenses is also included.

d/ CEP is a measure of the delivery accuracy of a weapon system. It is the radius of a circle within which half the weapons aimed at a target are expected to fall.

- o How many U.S. weapons would survive a Soviet attack now and in the future, after the Soviet Union improved the accuracy and destructive potential of its ICBM force?

- o How many of the surviving U.S. weapons would likely reach their targets in a retaliatory U.S. strike on the Soviet Union?

- o How much damage would they inflict?

HOW MANY U.S. WEAPONS WOULD SURVIVE A SOVIET ATTACK?

If the Soviet Union launched a massive, surprise nuclear attack against U.S. strategic nuclear forces today, portions of each component of the U.S. nuclear forces would be destroyed, but a potent U.S. retaliatory capability would remain. Those bombers that are normally on alert (30 percent under current policy) should survive, along with that portion of the U.S. submarine force at sea--about 55 percent of the Poseidon fleet. If, given current estimates of Soviet capabilities, the Soviets attacked the U.S. ICBM force with the most accurate missiles in their inventory, some 70 percent of the Minuteman force would be expected to survive.

With the full deployment of the Soviet SS-18 and SS-19 missile systems in the early-to-mid 1980s, 4/ fewer U.S. land-based ICBMs would survive a Soviet surprise first-strike attack. CBO's analysis indicates, for example, that only about 40 to 60 percent of the U.S. ICBMs portrayed in the finite deterrence force for the mid-1980s (see Table 2) would survive in such a situation. The number of ICBMs that would survive would be even fewer in the latter half of the 1980s (only about 10 percent), assuming the

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4/ SS-18 and SS-19 missiles are the most capable of the new Soviet missiles now being deployed. Each carries a large number of high-yield, independently targeted warheads (the SS-18 carries eight to ten; the SS-19 carries up to six) so that each missile would have the potential of destroying several Minuteman silos. Under the likely SALT II ceilings, the Soviet Union could deploy 308 SS-18 missiles; only 250 would be required to target two warheads on each of the 1,000 Minuteman silos.

Soviet Union would have deployed another generation of large, more accurate ICBMs by then.

But the number of surviving bombers would remain about the same in the next decade or more, assuming that about the same number would be on alert and could move away from the airfields targeted by the Soviet Union. Likewise, the number of surviving U.S. submarine-launched warheads would not be reduced by Soviet improvements in their nuclear forces. Instead, with the introduction of Trident submarines, the number of surviving submarine-launched warheads would probably increase in the 1980s because of additional submarines. In the 1990s, the number of surviving warheads would be about the same as today because the larger proportion of Trident submarines that would normally be at sea at any given time would compensate for the decrease in the size of the submarine force. (About 66 percent of the Trident submarine fleet would be at sea at any given time under normal day-to-day alert conditions, compared to roughly 55 percent of today's Poseidon fleet.)

These calculations were based on the assumption that the United States would have no warning of a Soviet nuclear attack before it was launched. If there were some warning and, in response, the United States heightened its alert status to what is termed a generated alert condition, the number of U.S. strategic nuclear forces that could be expected to survive a Soviet strike would be much larger. Table 4 shows the estimated surviving nuclear forces for both a surprise attack and one that occurs after a period of tension in which the number of forces on alert is increased. 5/

HOW MANY U.S. WEAPONS WOULD REACH SOVIET TARGETS?

Those weapons that survived a Soviet first strike must then be able to penetrate Soviet air space in order to reach their targets. Both land- and sea-based U.S. ballistic missiles launched in retaliation would probably face little opposition from a Soviet antiballistic missile (ABM) defense now or over the next

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5/ For a detailed discussion of the ability of U.S. forces to survive a Soviet first strike, see Congressional Budget Office, Counterforce Issues for the U.S. Strategic Nuclear Forces, Background Paper (January 1978), pp. 9-30.

TABLE 4. ESTIMATED U.S. STRATEGIC FORCES SURVIVING A HYPOTHETICAL SOVIET FIRST STRIKE (WARHEADS)

	Titan	Minuteman II	Minuteman III	Poseidon	Trident	SRAM	Bomb	Cruise Missile	Total
Current Forces									
Day-to-Day Alert	31	331	1,062	2,720	--	342	432	--	4,918
Generated Alert	31	331	1,062	3,968	--	912	1,152	--	7,456
Finite Deterrence Force									
Mid-1980s									
Day-to-Day Alert	10	205	753	1,920	1,984	336	236	1,000	6,444
Generated Alert	10	205	753	2,560	2,752	888	624	2,640	10,432
1990s									
Day-to-Day Alert	2	41	150	--	2,880	336	236	1,000	4,645
Generated Alert	2	41	150	--	3,968	888	624	2,640	8,313

SOURCES: The number of surviving bombers and submarines was computed from Tables 1-3 based on a 30 percent bomber alert rate, 55 percent for Poseidon and 66 percent for Trident submarines for the day-to-day alert case. For generated alert conditions, 80 percent of the bombers and submarines were assumed to be on alert. (See Department of Defense, Annual Report, Fiscal Year 1978, p. 133; and Fiscal Year 1978 Authorization for Military Procurement, Research and Development, and Active Duty, Selected Reserve, and Civilian Personnel Strengths, Hearings before the Senate Committee on Armed Services, 95:1 (April 1977), Part 10, p. 6621.) The number of surviving ICBMs for current forces is based on calculations using 1,840 warheads on 310 Soviet MIRVed missiles, all accurate to 1,500 feet CEP with 0.75 reliability and 2,000 psi (pounds per square inch) hardness for Minuteman silos. For the mid-1980s and 1990s ICBM forces, estimates are taken from Congressional Budget Office, Counterforce Issues for the U.S. Strategic Nuclear Forces, Background Paper (January 1978).

decade. 6/ U.S. bombers would face an extensive--but surmountable--network of air defenses. 7/ Bombers could choose their point of entry into the Soviet Union to minimize exposure to air defenses, concentrate to saturate the defenses, and use supersonic Short-Range Attack Missiles (SRAMs) to destroy surface-to-air missile (SAM) sites. Thus, estimates of the current capability of U.S. bombers to penetrate to their targets are as high as 85 percent. 8/ In other words, 17 out of every 20 bombers should be expected to reach their targets.

In the future, CBO assumes that the bombers in the finite deterrence force will maintain about the same level of capability--about four out of every five would penetrate to their targets--despite future Soviet air defense improvements. Soviet improvements could include an extended perimeter air defense based on airborne radars capable of long-range detection; a look-down, shoot-down interceptor (an aircraft capable of detecting and destroying low-flying aircraft and missiles) somewhat similar to the present U.S. F-14/Phoenix air-to-air missile system; and an advanced mobile surface-to-air missile system.

But for each presumed Soviet air defense development, there appears to be an adequate U.S. counter. Cruise missiles, which are expected to enter the finite deterrence force in the 1980s

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6/ ABMs are limited by treaty to the system now existing around Moscow, which is believed to be relatively ineffective. The Soviets are believed to be experimenting with a charged-particle beam weapon for defense against ballistic missiles. The problems of charged-particle beam generation, propagation, and pointing are such, however, that the successful development of a system that would be effective against ballistic missiles would appear to be far in the future. See Richard L. Garwin, "Charged-Particle Beam Weapons?" Congressional Record (July 27, 1977), p. S12931.

7/ Alton H. Quanbeck and Archie L. Wood in Modernizing the Strategic Bomber Force (Washington, D.C.: The Brookings Institution, 1976) cite estimates of 3 percent U.S. attrition in the 1972 December bombing raids against North Vietnam and 1 to 1.5 percent Israeli attrition in the 1973 war (see pp. 64-65).

8/ Ibid., p. 65.

and 1990s, could be launched before U.S. bombers could be attacked by Soviet air defenses. Cruise missiles are difficult to detect because of the small target they present to search radars and because their low-level flight further limits radar detection. The effective size of the missile as seen by a radar (radar cross-section) can be further reduced in the future. These characteristics, coupled with greater speed and maneuverability in the future, would defeat the Soviet mobile surface-to-air systems postulated for the next decade. In addition, cruise missiles are relatively inexpensive, permitting the procurement of large numbers that can saturate air defense systems.

If the Soviets do extend their air defense capability further from their borders by employing an Airborne Warning and Control System (AWACS), the United States could develop longer-range cruise missiles that could be launched before the bombers were detected, 9/ as well as improved electronic countermeasure (ECM) equipment and defensive missiles to shoot down Soviet interceptors. Finally, there are likely to be other factors that may compensate for Soviet air defense improvements. Ballistic missiles could be used to destroy Soviet airfields that support AWACS and fighters well ahead of the time bombers attempt to penetrate. (A first wave of bombers carrying supersonic attack missiles could also attack the fighter bases.)

Weapons that survive a Soviet first strike are expected to be very successful in penetrating Soviet air space. Because of the ABM treaty and the dim prospects for the development of types of defensive systems other than ABM missiles, the warheads that are successfully launched from ballistic missiles should reach their targets. Bombers and cruise missiles should be able to stay well ahead of Soviet air defense developments, as outlined above.

HOW MUCH DAMAGE WOULD BE INFLICTED ON THE SOVIET UNION?

The U.S. weapons that successfully penetrated Soviet air space would probably destroy roughly 90 percent of the military targets other than missile silos and about 80 percent of the Soviet industrial target base in the absence of extensive Soviet civil defense measures or efforts to harden industrial or military

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9/ This response would, of course, be eliminated as an option if a SALT II agreement severely limited cruise missile range.

targets. 10/ All Soviet governmental centers at the national and republic levels would be destroyed, as well as about half of the provincial centers. About 90 million people--over one-third of the total Soviet population--would be killed by the nuclear detonations and radioactive fallout.

Current Forces

Since each of the three components of the current nuclear forces could destroy over 75 percent of the Soviet industrial target base, current U.S. forces are considered to be well hedged against technological surprises. For example, in the highly unlikely event that the Soviets developed and quickly deployed a perfect ABM system (that is, one that could destroy all 4,000 incoming ICBM and SLBM warheads), the bomber force alone could destroy about 75 percent of Soviet industrial targets. 11/ The U.S. submarine and land-based missile forces could destroy about 90 percent of the Soviet industrial base or some 75 percent of both the general purpose military targets and the industrial target base--a good hedge against the rapid deployment of an advanced air defense system against bombers. The U.S. bomber and submarine forces could destroy some 85 percent of the Soviet industrial target base, or 65 percent of both the general purpose military and the industrial target base--a hedge against development of an effective Soviet capability to destroy Minuteman silos. Finally, U.S. bombers and ICBMs could destroy about 90 percent of the Soviet industrial target base or 70 percent of the general purpose military targets and the industrial target base in the unlikely event of a Soviet antisubmarine warfare (ASW) development that could negate the U.S. submarine force.

10/ To harden is to improve the protection afforded by structural shielding against the blast, heat, and radiation of nuclear explosions. (See Appendix A for a discussion of hardening methods.) These calculations assume half of the industrial targets are hardened to the extent that machinery will not be damaged if the buildings in which it is housed collapse.

11/ This assumes that only bombers are targeted against the industrial base. Less damage would be expected if all three force components were optimally allocated prior to the strike and then all the missile warheads failed to reach their targets.

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Thus, CBO's calculations confirm that current U.S. forces are capable of massive retaliation against the Soviet Union in the event of a nuclear war. Even after absorbing a surprise Soviet nuclear attack, enough U.S. warheads would survive to hit their intended targets and devastate the Soviet Union.

It is conceivable that, after such an exchange, the Soviet Union would still possess some ICBMs. None of the weapons currently in the U.S. inventory is particularly effective against hardened silos that house land-based missiles. 12/ But the United States would also possess nuclear power after an exchange. Sufficient weapons would remain in reserve to continue the conflict, if required, and to hedge against uncertainty in the results of nuclear war. 13/

Finite Deterrence Force

Over the next two decades, a number of factors could decrease the destructive potential of U.S. retaliatory capabilities. For one thing, Soviet industrial growth could increase the number of potential targets in the future. This, in turn, might increase the required number or capability of surviving U.S. nuclear forces that would be necessary to achieve about the same percentage of destruction as is now possible. Furthermore, hardening by the Soviets could reduce the effectiveness of weapons currently in the U.S. arsenal and could lead to a

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12/ The best current system, Minuteman III with a reported 0.17 megaton warhead and a 700 ft. CEP (see Table 1), would have a 0.40 probability of destroying improved silos (2,000 pounds per square inch (psi) hardness) with reliability included. This means that 1,400 Minuteman III warheads (out of an inventory of 1,650) would be expected to destroy only 500 Soviet silos. A bomb would be slightly more effective, with a 0.45 destruction probability, but would take much longer to reach the target than a missile system.

13/ In the force simulations, 1,000 U.S. warheads carried by submarines were withheld as a reserve. (See Appendix B for details.)

requirement for larger yield and/or improved accuracy. 14/ Finally, Soviet civil defense measures might also reduce the future effectiveness of U.S. nuclear forces. 15/

Yet, despite these factors, CBO's calculations suggest that a finite deterrence force, such as that outlined by Tables 2 and 3, would maintain a high level of destructive capability. By the mid-1980s, this baseline force would include Trident submarines, 10 Poseidon submarines carrying Trident I missiles, and cruise missiles carried by B-52 bombers. 16/ As Table 4 suggests, such a force would increase the number of U.S. warheads available for a retaliatory strike. (Over 6,000 weapons would be expected to survive a Soviet first strike, compared to 5,000 in the current forces.) The increased number of weapons and the newer systems would, in turn, improve the retaliatory effectiveness of the U.S. forces despite Soviet industrial expansion or hardening measures.

Thus, in simulating a U.S. retaliatory strike in the 1980s, CBO's calculations indicate the finite deterrence force could destroy over 80 percent of the industrial target base in the Soviet Union, assuming the number of separate installations did not increase. Soviet governmental control centers could be heavily struck, with 95 percent destruction expected at the republic level and over 50 percent at the provincial level. Over

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14/ "Superhard" targets such as ICBM silos are not expected to increase in number but may be hardened even further as a result of an ongoing Soviet modernization program. The effectiveness of current and proposed weapons for destroying Soviet silos is discussed in Congressional Budget Office, Counterforce Issues for the U.S. Strategic Nuclear Forces, pp. 31-44.

15/ The effects of Soviet civil defense measures to harden industrial targets and to save people are discussed in Chapter III.

16/ The projected U.S. forces for finite deterrence were based on fleet introduction of the Trident submarine in 1980 and assumed six years from authorization to delivery. To the extent that recent delays in the Trident program are not recouped by an increase in the production rate to two submarines a year in the 1980s, the capabilities of the finite deterrence force are somewhat overstated.

90 percent of the general purpose military targets could be expected to be destroyed. A reserve force of 1,000 submarine weapons was not used in these calculations in order to provide for possible growth in the industrial base and to continue the conflict, if required.

The forces for finite deterrence in the mid-1980s would also appear to be well hedged against technological surprise:

- o Should the Soviets deploy a perfect ABM system in the 1980s, the bomber force alone would have the capability of destroying 80 to 85 percent of the Soviet industrial target base, or 55 to 60 percent of both the general purpose military targets and the industrial target base.
- o Should the Soviets develop a perfect ASW system, the bomber and ICBM forces could be expected to destroy 85 to 90 percent of the Soviet industrial target base.
- o Should the Soviets deploy a perfect air defense system, ICBMs and submarine-based weapons could be expected to destroy over 90 percent of the Soviet industrial target base.
- o Should all U.S. ICBMs be vulnerable to Soviet attack, the bomber and submarine forces could destroy over 90 percent of the Soviet industrial target base, or 80 to 85 percent of both the general purpose military targets and the industrial target base.

CBO's simulations, then, suggest that the deployment of Trident and cruise missile systems, as postulated by the finite deterrence force, would both maintain the destructive potential of the current forces and improve the hedges against Soviet technological advances.

CBO believes that this situation would last into the 1990s. By that time, the Minuteman force could be vulnerable to a Soviet first strike with less than 10 percent of the force expected to survive a Soviet attack. Thus, fewer weapons--some 4,500 versus 6,000 for the mid-1980s force--would be expected to be available for a retaliatory strike.

But the higher yield of Trident I missiles compared to Poseidon missiles would permit the allocation of fewer weapons to industrial targets, while maintaining a damage expectancy of over

80 percent. Assuming that a reserve force of 1,000 Trident I warheads were withheld to hedge against industrial target growth and to continue a conflict if required, CBO's calculations indicate that the same high levels of expected damage to governmental centers could be achieved. The allocation of the remaining weapons to military targets could result in the destruction of over 90 percent of the Soviet general purpose forces.

The baseline forces of the 1990s would also provide a reasonable hedge against technological uncertainty, even if it is assumed that Minuteman silos would be vulnerable by that time. Either the bomber or the submarine force would, individually, be capable of destroying 75 to 85 percent of the Soviet industrial target base, depending on the growth in the number of new industrial plants. This capability would hedge against uncertainties in air defense, ASW, and ABM developments by the Soviet Union, as well as against U.S. ICBM vulnerability.

The results of the simulations are portrayed in Table 5.

TABLE 5. RETALIATORY CAPABILITIES OF THE FINITE DETERRENCE FORCE: PERCENT DAMAGE TO SOVIET TARGET BASE

	Current	Mid-1980s	1990s
Total Force a/			
Industrial target base	80	80	80
Military targets	90	90	90
Capability to Hedge Against Soviet Developments b/			
Against ABM: No ballistic missile warheads, only bombers attack			
Industrial target base only	75	80-85	75-85
Industrial and military targets	35	55-60	50-60
Against ICBM vulnerability: No surviving ICBMs, only bombers and submarines attack			
Industrial target base only	85	90	90
Industrial and military targets	65	80-85	75-85
Against ASW: No surviving submarines, only bombers and ICBMs attack			
Industrial target base only	90	85-90	80-85
Industrial and military targets	70	70-75	55-65
Against air defense: No bomber weapons, only submarines and ICBMs attack			
Industrial target base only	90	90	85-90
Industrial and military targets	75	75-80	60-70

a/ Weapons expected to survive a first strike are allocated to achieve over 80 percent damage to the industrial target base, assuming half were hardened to 30 pounds per square inch (psi). One thousand submarine warheads are held in reserve. The remainder of the weapons are allocated to military targets other than silos (at least one ballistic missile weapon is allocated to each military airfield and 100 SRAMs are allocated to air defense sites). No Soviet ICBM silos are included in the military target base.

b/ All surviving weapons of forces indicated are allocated; no weapons are held in reserve. For the mid-1980s column, the low end of the range assumes a 20 percent growth in industrial targets; the high end assumes no growth. For the 1990s column, the low end of the range assumes a 40 percent growth in industrial targets; the high end assumes no growth.

CHAPTER III. THE EFFECT OF SOVIET CIVIL DEFENSE MEASURES

To what extent would an effective Soviet civil defense program affect the potentially high level of destruction of the finite deterrence force? On the one hand, CBO's calculations suggest that an effective Soviet civil defense program could reduce the destructive potential of the current U.S. strategic nuclear forces, particularly if the Soviet Union launched a massive, surprise, first-strike attack on U.S. forces. But, on the other hand, it appears that an effective Soviet civil defense program would not escape the detection of the United States. U.S. nuclear forces would thus be alerted to an impending Soviet attack and, with a reallocation of targets, could recoup much of their destructive potential. Since efforts by the Soviet Union to harden industrial machinery and to evacuate population would likely be detected by the United States in enough time to place U.S. nuclear forces on an alert status, the number of U.S. weapons that should survive a Soviet first strike would likely be sufficient to achieve at least as much industrial and military destruction as would occur with no civil defense program.

Soviet fatalities could be reduced by an effective evacuation program. If the United States wanted to increase the number of expected fatalities, it should be prepared to hold enough survivable forces in reserve to continue the conflict for weeks or months after the initial nuclear exchange. The United States should also be prepared to provide target information to those forces. This would require survivable reconnaissance systems to identify targets as well as command and control systems to provide target data to the forces. This chapter examines these relationships in more detail.

THE SOVIET CIVIL DEFENSE PROGRAM

The Soviet Union has developed an extensive civil defense system. 1/ According to former Secretary of Defense Rumsfeld:

1/ See Appendix A for a description of the Soviet civil defense program.

> This civil defense capability--if it continues to grow as we expect--coupled with high accuracy and more reliable (Soviet) missiles, could adversely affect our ability to implement the U.S. deterrent strategy. Thus it could provide the Soviets with both a political and a military advantage in the event of nuclear crisis. 2/

Today's Soviet civil defense program is an outgrowth of an organization established in 1932 under the Soviet Ministry of Internal Affairs. In the early 1970s, A.T. Altunin was appointed to head the civil defense organization. Although there have been no major changes in the direction of the Soviet program since about 1972, efforts to reorganize and strengthen the program have been undertaken under Altunin's leadership. 3/

The Soviet civil defense program is designed to protect population through a shelter and evacuation program and to protect industry by shielding machinery and reducing damage from secondary effects such as fire. It is thought that the Soviets could make the transition to a war-ready posture in about three to four days if advance preparations were complete and in a week or so if they were incomplete. 4/

EFFECTS OF POPULATION PROTECTION MEASURES

The principal protective measures for the Soviet population include evacuation and the provision of shelters. In the absence of civil defense measures to protect the Soviet population, CBO's calculations indicate that about 95 million fatalities (or 35 percent of the population) and 10 million injuries (about 5 percent of the population) could be expected from a U.S. retaliatory strike following a massive, surprise nuclear attack by the

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2/ Department of Defense, Annual Report, Fiscal Year 1978, p. 107.

3/ Major General George Kolt, USAF, "The Soviet Civil Defense Program," Strategic Review (Spring 1977), pp. 51-67.

4/ Civil Preparedness Review, Report by the Joint Committee on Defense Production, 95:1 (April 1977), Part II, p. 71.

Soviet Union. If 60 percent of the Soviet population were evacuated to fallout shelters (30 percent in basements and 30 percent in special shelters) before an attack came, about 85 million fatalities and about 15 million injuries could be expected. Thus, shelters alone might not be adequate to reduce casualties significantly.

While evacuation of major cities would take some time, the number of expected fatalities could be reduced by moving people away from the vicinity of nuclear explosions. A moderately effective program might evacuate 50 percent of the urban dwellers and place 50 percent of the total population in shelters and another 25 percent of them in basements. Such a program would be expected to reduce fatalities to about 40 million and casualties to about 13 million. A more effective program could evacuate 75 percent of the people in the cities and place 70 percent of the people in shelters and 20 percent of them in basements. Fatalities in this case would be reduced to about 20 million and casualties to about 10 million people. 5/

Even with a very effective evacuation and shelter program, more than one out of every ten Soviet citizens would be expected to be killed or injured in a nuclear attack. These calculations, however, are based on U.S. forces that might survive a Soviet surprise attack while in a normal peacetime alert condition. Since an effective Soviet evacuation plan would take at least three days to implement and would likely be detected by the United States, U.S. nuclear forces would presumably be placed on alert. If so, some 1,200 additional Poseidon warheads and 1,300 more bomber weapons could be expected to survive a Soviet attack, in addition to the 5,000 weapons surviving under peacetime alert conditions. These 2,500 additional weapons could then be targeted against smaller Soviet cities (those with populations over 4,000) that were not previously targeted for attack. Such an attack could both significantly increase casualties and disrupt complex communal life by destroying shelters, medical facilities, and distribution systems.

Alternatively, the 3,500 surviving ICBMs and bomber weapons could be allocated to industrial and military targets while holding 4,000 Poseidon weapons in reserve. This weapon allocation would be expected to destroy some 80 percent of the Soviet

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5/ As a point of reference, there were over 20 million Russian casualties in the six-year period 1940-1945.

industrial target base despite hardening and 90 percent of the military targets. The large number of reserve weapons would permit continued attacks, assuming that adequate surveillance systems survived the Soviet attack. The more the Soviets concentrated their population on beginning reconstruction, the more effective further attacks would likely be. 6/ Such a prospect of continued death and destruction would militate against any Soviet belief that their civil defense program supported a "war-winning strategy."

EFFECTS OF INDUSTRIAL PROTECTION MEASURES

The second important component of the Soviet civil defense program is protection of industry. The most important aspect of industrial protection is the survival of critical machinery in an operable condition. Three levels of protection were considered in CBO's calculations. First, the Soviets were assumed to take steps to reduce the vulnerability of machinery to damage from secondary effects of nuclear detonations such as fire. Most of these measures fall under the heading of good housekeeping and were assumed to be accomplished in each damage expectancy calculation. 7/ The second level of protection would be measures to protect machinery from damage resulting from the collapse of buildings in which the machinery is housed. If permanent canopies and special foundations were constructed, overpressures on the order of 20-40 pounds per square inch (psi) would be required to achieve serious damage to heavy machinery. Finally, some machinery could be covered with sandbags or mounded with dirt. About 80 psi overpressure would be required to achieve serious damage levels in this case. 8/

Figures 1 through 4 illustrate the effects of industrial hardening on the independent capabilities of submarine and bomber

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6/ To carry out this strategy, the United States would require survivable reconnaissance assets to identify targets, a command center to designate targets to the forces that would survive a nuclear exchange, and some means of communication.

7/ No damage from secondary effects is included in the computations.

8/ See Appendix A, pp. 43-46.

weapons. The figures show the percentage of the industrial target base that would be expected to be destroyed if all weapons that survived a Soviet attack were targeted against industry. For example, in Figure 1, a force of 20 Poseidon submarines (11 would be expected to survive a Soviet surprise attack) would be expected to achieve over 85 percent damage to the industrial target base, assuming the targets were not hardened to resist nuclear effects. If all industries were hardened to 30 psi, the same number of submarine weapons would be expected to achieve only 50 percent destruction. Of course, all machinery could not be so hardened, so the damage in an actual strike would be greater.

More extensive hardening measures could further reduce the effectiveness of Poseidon weapons. Figure 1 also illustrates the damage expectancy if all industry were hardened to 80 psi. In this case, it is assumed that such measures would be detected by the United States in time to alert the submarine force, so that it would survive a Soviet attack. Even so, these submarines would be expected to destroy less than 50 percent of the industrial target base. The effect on the retaliatory capability of this force would depend on how many plants could be hardened, on the type of industry, and on the inherent resistance of the machinery to nuclear effects.

The increased yield of Trident I missile warheads would make them more effective against harder targets, as shown in Figure 2. The 16 Trident submarines surviving out of a force of 20 submarines could, under generated alert conditions, destroy over 75 percent of the Soviet industrial target base even if all machinery were hardened to 80 psi. The replacement of Poseidon missiles by Trident missiles will improve the U.S. capability to counter Soviet civil defense measures.

Bombs, with their larger yield, are less affected by hardening, as shown in Figures 3 and 4. Increasing industrial hardness to 30 psi would have little effect on expected damage from bombs. For example, with 360 bombers in the force, 100 would be expected to survive a first strike, assuming normal peacetime alert. These bombers would be expected to destroy about 70 percent of the Soviet industrial target base without hardening. Some 65 percent of the industrial target base might be destroyed by the same 100 bombers even if hardened to 30 psi. Twice as many weapons would be available if the force was on generated alert, and these could achieve greater damage expectancy in the unlikely case that all industry was hardened to 80 psi. The 288 surviving bombers on generated alert (of a force of 360) would be expected to destroy over 80 percent of the industrial target base.

Figure 1

Effect of Industrial Hardening on Poseidon Effectiveness

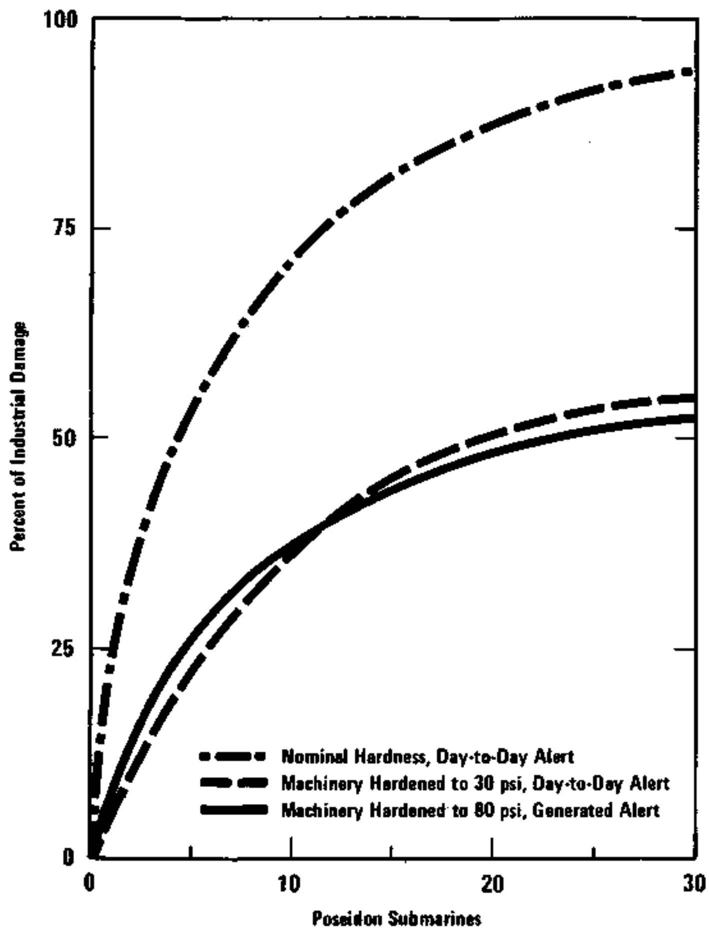


Figure 2.

Effect of Industrial Hardening on Trident Effectiveness

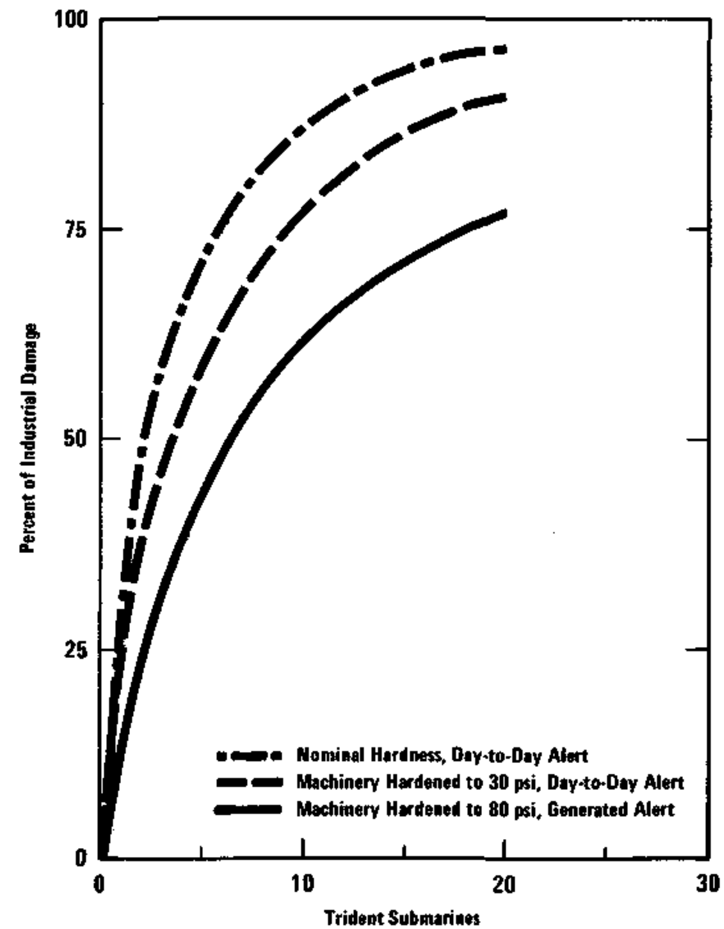


Figure 3
Effect of Industrial Hardening on Bomb Effectiveness

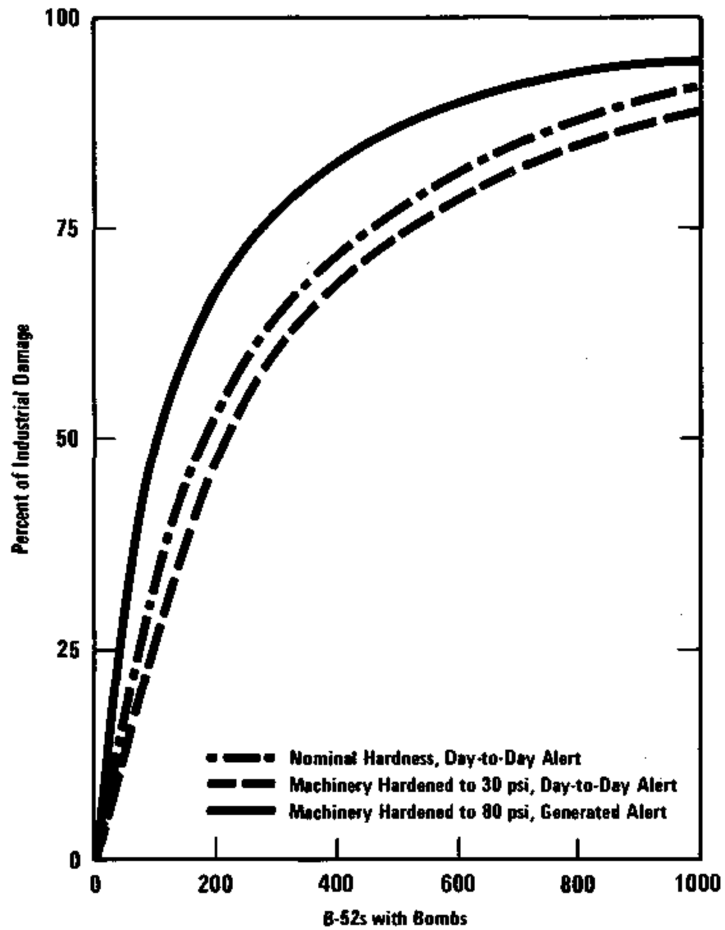
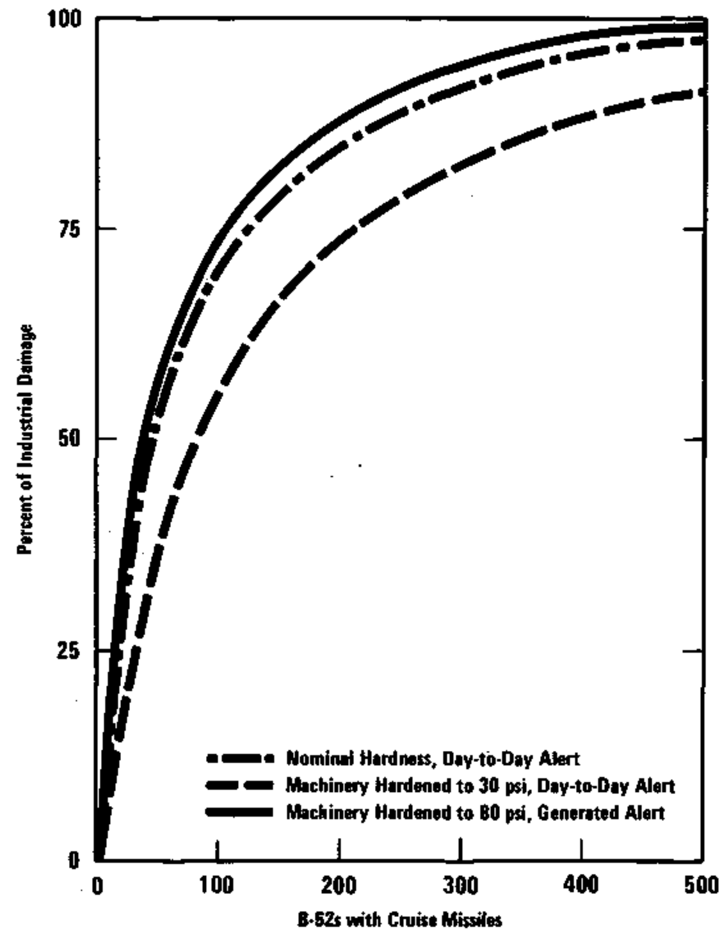


Figure 4
Effect of Industrial Hardening on Cruise Missile Effectiveness



If cruise missiles were used, fewer bombers would be required for an attack on Soviet industry because each bomber could carry a larger number of weapons. For example, a force of some 200 B-52s (60 surviving under peacetime alert) with cruise missiles would be sufficient to achieve 85 percent damage to the industrial target base, assuming no hardening. This force could destroy about 75 percent if all the industrial targets were hardened to 30 psi. An extensive Soviet industrial hardening program would take time and would probably be conducted in conjunction with an evacuation plan. If U.S. intelligence should detect such Soviet activities, the nuclear forces would be alerted. The number of bombers that would be expected to survive a Soviet attack would be increased significantly. The larger bomber force would be expected to destroy about 85 percent of the industrial target base.

Protection of machinery from damage resulting from building collapse could be an effective civil defense measure for the Soviet Union. All industry is not amenable to such efforts, but the proportion is unknown. Clearly, it is important to identify those industries that use machinery that is naturally resistant to blast damage, such as lathes and milling equipment, and to allocate more destructive weapons, such as bombs or cruise missiles, to those targets. If such an allocation were made, current and projected U.S. forces would be capable of destroying a high percentage of industrial targets with only a marginal increase in the number of weapons allocated to them. The deployment of cruise missiles would increase the capability of the bomber force to destroy hardened industrial targets because cruise missiles are nearly as effective as bombs and many more can be carried on a B-52. Similarly, Trident I missiles will be more effective against industrial hardening than the Poseidon missiles which they will replace.

CHAPTER IV. RETALIATORY FORCE STRUCTURE

A number of general criteria have traditionally been used by planners as guides to sizing and structuring U.S. nuclear forces. Many of these criteria have been accepted by the Congress and probably will continue to be employed in the future.

One major criterion might be a called a conservative, or "worse-case" orientation toward estimating U.S. force requirements. 1/ That is, in planning strategic nuclear forces, very demanding situations are assumed--such as considering what forces would be necessary to achieve various levels of destruction against the Soviet Union, even after the United States had absorbed a massive, surprise nuclear strike. In calculating these requirements, planners often give the Soviet Union the benefit of the doubt in areas of technical uncertainty. These biases are generally supported by the Congress because of the risks of not having enough strategic nuclear forces. There is a national consensus that, in the strategic nuclear relationship between the United States and Soviet Union, there should be little or no question that the price paid for a nuclear strike against the United States would be very, very high. This orientation has been adopted in CBO's calculations.

Other general criteria are also used in determining U.S. force requirements. Prudence, for example, might dictate that the United States not only maintain enough potential destructive power to devastate the Soviet Union in a retaliatory attack, but also hold additional forces in reserve to continue a nuclear exchange or to deter other nuclear powers from trying to take advantage of the United States in the aftermath of a nuclear war. CBO's calculations have assumed a sizable reserve force. 2/

1/ See Appendix B for a discussion of assumptions.

2/ The number of weapons that should be procured for the reserve role is a matter of judgment, but it is clear that a reserve force should be survivable and capable of responding to national direction in a post-nuclear environment. Submarine-based missiles would be a very secure basing system for a

Likewise, some requirements might exist for what has been termed a limited nuclear strike option--that is, a U.S. decision to attack a very limited number of targets in the Soviet Union in order to show resolve during a crisis or to respond to a limited Soviet strike. CBO did not specifically allocate any weapons for this mission because it would precede a massive Soviet first strike against U.S forces and would alert the U.S. strategic nuclear forces.

U.S. RETALIATORY FORCE OPTIONS

Since the advent of the nuclear age, much analytic effort has been devoted to generating nuclear force requirements that meet the above, as well as a wide range of other planning, criteria. A great deal of uncertainty accompanies these efforts, however. While U.S. weapons reliability can be determined with some precision, the future effectiveness of Soviet defenses or of programs to harden their industries and protect their command and control facilities against the effects of a nuclear attack are necessarily more difficult to measure. And there is always the chance of an unexpected technological breakthrough by the Soviet Union that could severely challenge the validity of the calculations that enter into planning criteria.

Finally, even if the calculations outlined in this paper were roughly accurate, two major questions would remain: Would Soviet decisionmakers make the same assessment as U.S. leaders of the ultimate results of a nuclear exchange? Whatever their assessment, would it deter them from initiating the exchange?

There are no clear answers to these questions. In broad terms, the Congress has several alternatives. It could accept the vulnerability of the current ICBM force, rely primarily on the bomber and submarine forces, and move into the future with what has been described as a finite deterrence force. Or it could seek

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reserve force because of their survivability, reprogramming capability, and ability to continue to operate for long periods following a nuclear exchange. For the purpose of estimating force effectiveness in this paper, 1,000 surviving warheads in nuclear submarines were set aside for a reserve force and were not included in the calculations of total force effectiveness.

to maintain the three survivable strategic force components and procure new generations of land-based ICBMs like the MX. Alternatively, it could seek to improve further the sea-based or air-based capability.

A Finite Deterrence Force

The finite deterrence force--used as the baseline in this paper (see Tables 2 and 3)--could inflict severe damage in retaliation against Soviet governmental centers, industry, and military targets (other than ICBM silos) despite possible civil defense measures. This force structure would also provide a large reserve force to hedge against an increase in the number of targets, civil defense measures, and the uncertainty inherent in nuclear conflict. The bomber and submarine forces would each have an independent capability to destroy most of the Soviet industrial target base. Those who believe that these capabilities represent an adequate deterrent might see little rationale for developing additional nuclear forces such as the MX, Trident II, or cruise missile carriers. The finite deterrence forces would cost about $120 billion (in fiscal year 1979 dollars) for procurement and operating costs from fiscal years 1979 through 2000. 3/

Maintaining a Survivable Land-Based Missile Force

There may be concern about the robustness of the hedges available in the finite deterrence force. While there would always be great uncertainty involved, U.S. and Soviet planners could assume that a massive Soviet first strike in the late 1980s could destroy nearly the entire U.S. land-based Minuteman ICBM force, even under the restraints likely to be imposed by a SALT II or subsequent agreement. Thus, a commitment to the finite deterrence force would carry with it a conscious decision to shift away from a survivable land-based missile component of the strategic

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3/ The B-52 and KC-135 tanker forces will probably have to be replaced in the early 1990s. If the B-52 force is replaced with a comparable mix of advanced penetrating bombers and wide-bodied cruise missile carriers and if wide-bodied aircraft replace the present tanker force, then an additional $35-45 billion (in fiscal year 1979 dollars) would have to be spent in the 1990s to maintain a strategic bomber force.

nuclear forces and to forego the additional hedges against Soviet technological breakthroughs in air defense or antisubmarine warfare that could be provided by survivable, land-based ICBMs. The combination of U.S. ICBM silo vulnerability, a very effective Soviet civil defense program, and the development of an effective Soviet air defense, for example, could seriously reduce the capabilities of the finite deterrence force. Since it is most unlikely that all these events would occur over the next two decades, the finite deterrence forces should continue to be capable of great destruction in a retaliatory strike against the Soviet Union. If one is concerned about the possible simultaneity of these events, however, the importance of maintaining a secure strategic deterrent could justify the investment of additional money in U.S. nuclear forces.

One reaction to such concerns could be to move ahead with the development and deployment of the MX mobile missile. The procurement of 300 MX missiles would enhance the capability of the retaliatory forces. Compared to the finite deterrence force, for example (see Tables 2 and 3), such a force structure would improve the hedges against ICBM vulnerability and Soviet developments in air defense and antisubmarine warfare. Three survivable force components would be maintained, each one independently capable of destroying most of the Soviet industrial target base in a retaliatory strike. MX would also provide a capability to attack Soviet silos, because of the larger yield and better accuracy. This program would add $30 billion (in fiscal year 1979 dollars) to the costs of the strategic forces, assuming that 300 Minuteman missiles were retired, for a total cost of about $150 billion over the 22-year period of fiscal years 1979 to 2000.

Other Options

To increase the hedges against Soviet breakthroughs in air defense and antisubmarine warfare, the capabilities of both the submarine force and the bomber force would have to be improved. Additional submarines with Trident I missiles or better weapons such as Trident II would improve the hedge against Soviet air defense improvements. Increasing the number of cruise missiles in the bomber force would improve the hedge against Soviet antisubmarine warfare developments.

Criteria other than retaliatory capability must be considered in determining U.S. strategic force posture, however. There may be concern about possible asymmetry in counterforce capability in

that the Soviets could threaten an attack against Minuteman silos but the United States would have no comparable capability against Soviet silos. How the strategic balance may be perceived by allies and other nations, as well as the effect of new procurement on strategic arms control negotiations, is also important. A forthcoming CBO budget issue paper will discuss these issues as well as force requirements for a U.S. capability to destroy Soviet silos.

APPENDIXES

APPENDIX A. SOVIET CIVIL DEFENSE

Soviet military thought seems to reflect a straightforward approach to nuclear warfare--once deterrence fails, nuclear weapons should be employed with whatever intensity is necessary to defeat the enemy. 1/ Soviet nuclear doctrine apparently emphasizes enemy military forces as the primary targets for their weapons, followed closely by industry and political/administrative control centers. Civil defense is important to the Soviets as a logical contribution to minimizing damage from nuclear weapons and continuing the war effort. It is possible that an effective civil defense program could intimidate U.S. leaders during a crisis because, having evacuated their people and protected their industry, the Soviets could threaten U.S. cities without endangering their own.

The Soviet Union has developed an extensive civil defense system. Soviet leaders have repeatedly stated that their "civil defense is a threat to no one and has always pursued humane goals." 2/ It is possible that the Soviet civil defense program is indeed designed for the Soviet Union's own protection in case war is inflicted upon it and is not aimed at achieving a capability to "win" a nuclear war. Still, a nuclear war would disrupt their political and social system, so that the mere existence of passive defenses would not necessarily make beginning a war attractive to Soviet leaders. V.I. Chuikov, former Soviet Chief of Civil Defense, has said, however, that the defensive strength of a country is based not only on the ability of its armed forces to wage war, but also on the ability to maintain a level of industrial and agricultural production during a conflict to assure

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1/ See Benjamin S. Lambeth, Selective Nuclear Options in American and Soviet Strategic Policy, R-2034-DDRE (Santa Monica: Rand Corporation), December 1976.

2/ A. Tolkunov, "In the Light of Day," Pravda (September 12, 1977), p. 5, reprinted in "Western Hemisphere," The Current Digest of the Soviet Press (October 12, 1977), p. 17.

its successful conduct and the country's subsequent recovery. 3/ According to former Secretary of Defense Rumsfeld, continued growth of Soviet civil defense--coupled with high accuracy and more reliable (Soviet) missiles--could adversely affect the ability of the United States to implement its deterrent strategy. 4/ The effectiveness of the Soviet civil defense system and its effect on weapons requirements must therefore be considered in developing a U.S. deterrent posture and in sizing required forces.

HISTORY

Today's Soviet civil defense program is an outgrowth of the Main Administration of Local Anti-Air Defense System (MPVO), which was established in 1932 and was directed by the Soviet Ministry of Internal Affairs. This system consisted of many organizations in areas, primarily along Soviet borders, that were particularily vulnerable to attack. In the early 1960s, MPVO was renamed Civil Defense (GO), and direction of the program was transferred to the Soviet Ministry of Defense. This change reflected the development of Soviet thought concerning civil defense. With the advent of nuclear weapons, the Soviet Union realized that it is necessary to protect more than just border targets. Therefore, civil defense has become an integral part of the overall Soviet defense capability and, as such, is coordinated with other defense plans. In the early 1970s, the leadership of the civil defense organization passed to A.T. Altunin, who has since been appointed General of the Army. Under his leadership, a much needed reorganization and revivification of the Soviet civil defense program has taken place.

THE RESPONSIBILITIES AND STRUCTURE OF THE SYSTEM

The Soviet civil defense program is responsible for the protection of Soviet leadership, industry, and population. This

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3/ Leon Goure, War Survival in Soviet Strategy: USSR Civil Defense, Monographs in International Affairs (Miami: University of Miami Center for Advanced International Studies, 1976), p. 47.

4/ Department of Defense, Annual Report, Fiscal Year 1978, p. 107.

involves familiarization of civilians and military personnel with defense plans, protection of agriculture and water supplies, dispersal and hardening of vital industries and services, emergency repair and restoration work, and assistance in natural disasters. Soviet officials have observed that civil defense measures are designed to enhance the country's "ability to rapidly liquidate the consequences of enemy nuclear strikes, promptly render extensive and diverse aid to casualties, and secure the conditions for the more normal functioning of the facilities of the national economy." 5/

The Soviet civil defense program is supported by a large, primarily military staff. It operates through three major channels: the administrative government; industrial, agricultural, and educational organizations; and a military civil defense organization. A civil defense staff is incorporated into every socialist republic government, with subordinate staffs in the local governments of oblasts (districts), rayons (regions), and towns (see Figure A-1). 6/ Each industrial, agricultural, and educational ministry has a civil defense staff that is responsible for civil defense formations in almost every factory, farm, and school. All industrial and nonindustrial installations, laboratories, schools, and farms must have their own plans for civil defense. 7/

Training in civil defense begins in the grammar schools, where short courses are given starting with the second grade, and in Pioneer recreation camps, where most Soviet children spend two weeks every summer. Since 1967, each pupil must, in the last two years of school, have pre-induction military training that includes a comprehensive review of civil defense and first aid. University students take a 50-hour course qualifying them to be civil defense instructors or leaders of paramilitary units.

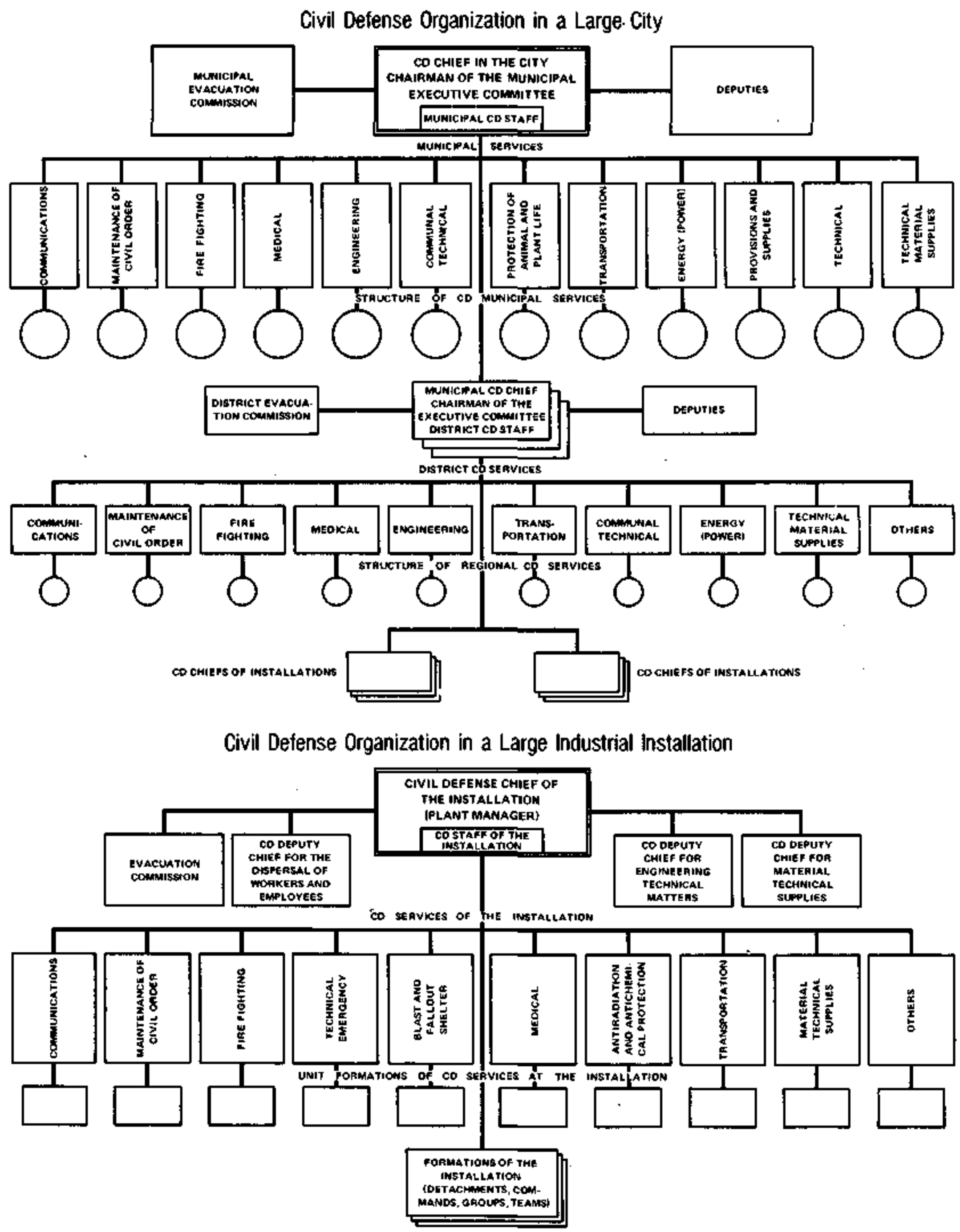
5/ Dennis Ross, Rethinking Soviet Strategic Policy: Inputs and Implications, ACIS Working Paper No. 5 (Los Angeles: University of California Center for Arms Control and International Security, June 1977), p. 8.

6/ C.N. Donnelly, "Civil Defense in the Soviet Union," International Defense Review (August 1977), pp. 635-637.

7/ Peter Kruzhin, The Streamlining of Civil Defense in the USSR, RL 415/76 (Radio Liberty Research, September 22, 1976), p. 11.

Figure A-1

Soviet Civil Defense



A 20-hour course followed by an examination is mandatory for the entire work force. 8/

There are two major programs that train military officers for civil defense: the Moscow Military Academy of Civil Defense of the Soviet Union and the Higher Central Courses for Civil Defense Officers of the Soviet Union.

The Military Civil Defense Forces branch of the Soviet armed forces trains and directs a large part of the civilian civil defense program as well as coordinates the military civil defense role within the armed forces. A number of Army regiments (not at full strength) are responsible for restoring communications and for providing other services necessary to mobilize the country for a war effort. Over 100,000 full-time civilian and military personnel are apparently involved in the Soviet civil defense program. 9/

Among the different groups contributing to civil defense are the Civil Defense Communications Service (under local post offices), the Service for the Maintenance of Civil Order (under the local police), the Engineering Service (under local building agencies), the Communal Technical Service, the Animal and Plant Life Protection Services, and the Transport Service.

The Soviet civil defense organization can be compared to the U.S. civil defense system as a point of reference. The U.S. system consists of many federal agencies as well as state and local agencies. The three major components--employing about 1,500 people--at the federal level are the Defense Civil Preparedness Agency, whose director reports directly to the Secretary of Defense; the Federal Preparedness Agency, under the General Services Administration; and the Federal Disaster Assistance Administration, under the Department of Housing and Urban Development. No central authority connects the various U.S. programs, although they do function somewhat in partnership with each other. Other organizations that aid U.S. civil defense efforts are the National Weather Service, the Law Enforcement Assistance Administration, the U.S. Army Corps of Engineers, and

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8/ Major George Kolt, USAF, "The Soviet Civil Defense Program," Strategic Review (Spring 1977), pp. 54-55.

9/ Department of Defense, Annual Report, Fiscal Year 1979, p. 52.

the Department of Health, Education, and Welfare. 10/ At the state and local level, some 4,700 state and local jurisdictions--employing some 5,400 people--are involved in civil defense activities. Training is conducted at the Civil Defense Staff College. 11/

PROTECTION OF THE SOVIET POPULATION

In the 1960s, the Soviets developed a plan to protect their population in case of nuclear war. The program consists of major efforts to shelter the leadership--political, military, and Communist Party--in very substantial protective structures, a lesser effort to protect key workers in less effective shelters, and an evacuation scheme for the bulk of the population. 12/ The Soviet plan to protect its workers relies heavily on evacuation, although the pace of shelter construction has increased in recent years. The goal of the program is to provide shelter for half of the work force in cities and to evacuate the remaining off-shift workers outside the cities. 13/

The plan for the remainder of the population is evacuation into the countryside and the quick building of simple shelters. Field experiments conducted by the United States, following instructions from the Soviet Civil Defense Manual, "have demonstrated that, with only written instructions and available tools and materials, untrained civilians can within two days

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10/ U.S. General Accounting Office, Civil Defense: Are Federal, State, and Local Governments Prepared for Nuclear Attack? LCD-76-464 (August 8, 1977), pp. 1-6.

11/ Fiscal Year 1978 Authorization for Military Procurement, Research and Development, and Active Duty, Selected Reserve, and Civilian Personnel Strengths, Hearings before the Senate Committee on Armed Services, 95:1 (April 1977), Part 10, p. 6940.

12/ Interview with Secretary of Defense Harold Brown, U.S. News and World Report (September 5, 1977), p. 21.

13/ Military Posture and H.R. 5068 (Department of Defense Authorization for Appropriations for Fiscal Year 1978), Hearings before the House Committee on Armed Services, 95:1 (February 1977), Part 6, pp. 212-213.

construct expedient shelters enabling them to survive at least 15 psi shock overpressure and the most intense fallout radiation likely to be encountered." 14/

Planning for the protection of the population in the Soviet Union includes a combination of physical, military, and civil defense training as well as psychological indoctrination. Implementation of such a large-scale and administratively complex program is not without shortcomings. There are difficulties in planning the evacuation of large numbers of people from cities, and major problems could be expected if a plan were implemented by people who had not received training. Moreover, while the urban population in the Soviet Union is increasing, the pace of construction of hardened shelters in Soviet cities is proceeding slowly. The outlying districts are also becoming urbanized and, consequently, even with evacuation, population density in many areas would be quite high.

Several studies in recent years have focused on the Soviet evacuation program and speculated on its effectiveness. A report to the Joint Committee on Defense Production of the U.S. Congress by the Boeing Aerospace Company in November 1976 stated that: 15/

> If the Soviet urban population remains in the cities, the Soviet Union would lose most of its industrial work force. Even use of urban shelters would not help much against a U.S. attack designed to destroy population. However, using only minimal dispersal--such as could be obtained by ordering the population to walk for one day away from the cities--fatalities could be significantly reduced if simple shelters of the type shown in Soviet manuals were constructed or if the U.S. followed a policy of retaliating

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14/ Conrad V. Chester and Eugene P. Wigner, "Population Vulnerability: The Neglected Issue in Arms Limitation and the Strategic Balance," Orbis (Fall 1974), pp. 763-769.

15/ "Industrial Survival and Recovery after Nuclear Attack," a report to the Joint Committee on Defense Production, in Defense Industrial Base: Industrial Preparedness and Nuclear War Survival, Hearings before the Joint Committee on Defense Production, 94:2 (November 17, 1976), Part I, p. 65.

> against industrial targets. A full 3-day evacuation of the type called for in Soviet plans would reduce fatalities [from the immediate blast and short-term fallout effects] to no more than 10 million people. This latter figure approximates that given by a Soviet civil defense text.

These high survival figures are based upon optimistic expectations of the possible success of the Soviet evacuation system. The Soviets have not publicized results of their evacuation drills, if they do indeed have drills, so it is not clear that these high survival rates could be achieved under wartime conditions. 16/

If there were follow-on nuclear strikes by the United States, the evacuation plan could be much less effective: 17/

> The more the Soviets concentrated population to begin reconstruction in the aftermath of a first or second phase of attack, the more effective further attacks would be. The more they dispersed to avoid such consequences, the slower recovery would go forward. In addition to the effects of concussion, firestorm, and radiation, there would be the incalculable tolls of disease, infirmity, and disruption of complex communal life.

PROTECTION OF SOVIET INDUSTRY

The basic methods for protecting industry include dispersal, bomb-resistant construction, protection of critical machinery, and fire-protection. During a crisis, industry can either maintain full production, maintain some output, convert to a more needed product, or close down production entirely in order

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16/ It should be noted that U.S. civil defense plans include the provision of community shelters for 80 percent of the population, local plans for feeding 125 million people in group shelters, and prepared releases for radio, television, and newspapers to provide the requisite information when required.

17/ Thomas H. Etzold, "Soviet Civil Defense and U.S. Strategy," Air Force Magazine (October 1977), p. 39.

to be hardened against nuclear effects. The Soviet Union is apparently concerned that key industries be able to remain at least partially operational in order to allow the successful conduct of a nuclear war. It is not clear, however, how such production would contribute, even if a conflict occurred in Western Europe. It is usually assumed that a conventional war between NATO and Warsaw Pact forces in that area would end before production would have any influence. Soviet doctrine does not appear to be consistent on this point. The protection of essential machinery is necessary, however, for a timely recovery after a war.

Dispersal of Industry

Dispersal of industry is frequently mentioned as an important contributor to industrial survival. The Soviet Union has built many new factories outside of existing urban concentrations, but most industrial siting remains a function of economic considerations such as proximity to labor, new or existing sources of power, markets, raw materials, and transportation. 18/ There are also other kinds of dispersal, such as locating new factories far enough apart so that a single small warhead could not destroy two adjacent factories or by locating individual buildings within a factory far enough apart so that more than one small weapon would be necessary to destroy an entire complex. Of course, the United States has a plethora of small weapons which could negate these measures.

Finally, dispersal can involve the crisis relocation of a few critical industries. In World War II, the Soviets were able to move all equipment out of a single factory in about 10 days. 19/

18/ Civil Preparedness Review, Report by the Joint Committee on Defense Production, 95:1 (April 1977), Part II, pp. 75-76. One such example would be the Kama River truck plant, which produces 20 percent of the trucks in the Soviet Union. The value of this kind of construction with respect to civil defense is questionable, since this site is more concentrated than U.S. production. Although located away from existing facilities, this plant simply becomes one more large target.

19/ Defense Industrial Base: Industrial Preparedness and Nuclear War Survival, Hearings, Part I, pp. 69-71.

This type of dispersal requires more time than is normally assumed to be available prior to a strike and would enable the United States to put its forces on alert.

Protection of Machinery

Generally, industrial buildings suffer significant damage at 2 to 5 pounds per square inch (psi) overpressure and total destruction at 10 psi. Unprotected pieces of machinery can often withstand greater overpressures if they are located in open areas, but they then become vulnerable to damage from the collapse of buildings adjacent to them. Different protective measures have been tested by the Soviet Union, including the construction of permanent in-place hardened canopies, hoods, massive tie-down efforts, and foundations that increase to 20 to 40 psi the overpressure required to overturn and seriously damage machinery. These methods, however, have only limited application, since they are prohibitively expensive and could require extensive factory remodeling. 20/

Another type of protection is to sandbag or earthmound machinery. This is a less expensive method that can protect machinery to overpressures up to 80 psi 21/ and from falling debris from the building in which it is housed. The effectiveness of sandbagging and earthmounding measures is limited by the soil motion brought on by a nuclear explosion and by the fact that the machinery cannot be used while covered. Also, the machinery is susceptible to corrosion unless it is properly treated before it is covered. Boeing Industries has conducted experiments expanding on this Soviet concept in which machinery was first surrounded by a crushable material, such as industrial chips (the debris that results from milling operations), and then packed with earth. This method has increased the protection factor up to 200 to 300 psi. It is not known whether the Soviets have considered expanding on this concept beyond their published sandbagging technique. A practical application of the Boeing method would involve protecting half of a factory's critical machinery, while leaving the remaining half in operation, or closing down

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20/ Ibid., pp. 80-87.

21/ Ibid., p. 87.

production entirely in order to enhance the possibility that a factory would survive a nuclear attack. 22/

Another protection method discussed in Soviet literature is submersion of machinery. Some machines do not lend themselves to being packed in dirt. In such cases, water can sometimes provide a good alternative. After treating the machines with grease or spray paint to protect them against corrosion, they can be quite successfully submerged by creating a tank with sandbags. The tank is then covered to protect the machinery from falling debris. This can be accomplished in one or two days and is an inexpensive method, but it has all the disadvantages of sandbagging.

Other simple, expedient steps can be taken to protect machinery by removing fire hazards from the immediate area. This involves locating fuel storage sites away from critical machinery and training personnel to shut off machines and electrical power before evacuating to shelters. Secondary effects from a nuclear blast, such as fire or shorts in electrical systems, can damage machinery just as effectively as primary effects can.

THE CURRENT STATE OF SOVIET CIVIL DEFENSE

It is known that the Soviets are prepared to protect some of their critical industries in order to make them less vulnerable both to secondary effects from nuclear explosions and to the effects of distant detonations. The Soviet civil defense program has begun to require that all service and industrial facilities provide protection for their most valuable machinery and the electrical power, steam, water, and chemical conduct systems; establish underground electrical and telephone lines, water reservoirs, pumping, and transformer stations; and protect their fuel. 23/

It is thought that the Soviets could move into a war-ready posture in three to four days if advance preparations were

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22/ Ibid., pp. 87-89, 106-107.

23/ Leon Goure, Soviet Civil Defense in the Seventies, prepared for the U.S. Defense Civil Preparedness Agency (Miami: University of Miami Center for Advanced International Studies, 1975), pp. 66-74.

complete and in a week or so if they were incomplete. 24/ Recent studies have not indicated any major changes in the direction of the Soviet program since about 1971, but they do indicate that the Soviets are progressing with their civil defense programs. 25/ The Department of Defense concluded that, "overall, there has been no significant reduction in the vulnerability of Soviet industry to nuclear attack." 26/

24/ *Civil Preparedness Review*, Report, Part II, p. 71.

25/ "Soviet Civil Defense: Insiders Argue Whether Strategic Balance is Shaken," *Science* (December 10, 1976), p. 1142.

26/ Department of Defense, *Annual Report, Fiscal Year 1979*, p. 48.

APPENDIX B. SNAPPER DAMAGE ASSESSMENT MODEL: INPUT DATA AND MAJOR ASSUMPTIONS

The calculations in this paper are based on the SNAPPER Damage Assessment Model developed for the Air Force by the Rand Corporation. 1/ The model provides a rapid means of calculating the destruction expected from the detonation of a large number of weapons, given explicit assumptions about target and weapon characteristics. It does not incorporate operational planning constraints such as range or footprints.

TARGETS

The model includes an industrial target base of some 1,400 general industrial areas and specific industrial plants in the Soviet Union that are essential to economic and military recovery. It also includes a military target base of some 1,300 military airfields, naval bases, army depots, and nuclear storage sites. 2/ A population data base is also part of the model.

1/ Bruce W. Bennett, The SNAPPER Nuclear Damage Assessment Model, WN-9899-AF (Santa Monica: The Rand Corporation, June 1977).

2/ These target bases have been chosen as reasonable representations of what U.S. forces might attack. Of course, they do not include all Soviet industrial and military installations, but they should include the major ones. Designating targets by specific industrial complexes rather than large metropolitan areas permits a more accurate assessment of weapons requirements. When the targets are specified as large metropolitan areas, calculations are sometimes presented solely in terms of equivalent megatonnage, without regard to the numbers of weapons involved. For example, the annual Defense Department report for fiscal year 1969 estimated that about 400 equivalent megatons would be sufficient to destroy half of Soviet industry (see Department of Defense, Annual Report, Fiscal Year 1969, p. 50). Allocating weapons to plants, as is done in the SNAPPER model, tends to emphasize the number of weapons in addition to their yield. From

The analysis is structured so that an overall objective regarding industrial damage is translated into specific objectives for individual sectors. In other words, if an attack is designed to achieve 80 percent damage to all industrial installations in the target base, then weapons are allocated to destroy about 80 percent of steel production and about 80 percent of refinery capacity.

All military targets in the target base (except ICBM silos) are grouped together in a target set. Each class in the set--airfields, naval bases, army depots, nuclear storage sites--is given roughly the same value (that is, all airfields are as important as all army depots). It should be noted that military bases make up the target set rather than forces (such as ships and tanks). It is difficult to estimate damage to mobile units such as tanks because they may be moved to the field prior to the arrival of the nuclear weapons. Although the targeting of bases is used to estimate weapon requirements, whether or not such an allocation should be made in an actual strike would depend on events leading up to the crisis and on the amount of intelligence available on troop movements.

Population is not directly targeted in the SNAPPER model, but casualties are computed based on weapon aim points (which depend on the target allocation) and the location of population. Prompt effects from blast and radiation are computed using standard Defense Intelligence Agency methodology. Fallout effects are calculated using a fallout model developed by the Weapon System Evaluation Group.

MAJOR ASSUMPTIONS

As in any model, the results generated depend on the series of assumptions made regarding the necessary inputs. The following categories are among the most important in this model.

Figures B-1, B-2, and B-3 (below), about 1,200 Poseidon warheads with 140 equivalent megatons, 900 cruise missiles with 300 equivalent megatons, or 700 bombs with 700 equivalent megatons would achieve the same 80 percent expected damage to the industrial targets in the SNAPPER base. Equivalent megatons, then, is a poor indication of the destructive power of an arsenal against industry when damage is assessed against individual plants rather than metropolitan complexes.

Surviving Weapons

All the calculations of damage inflicted upon the Soviet Union are based on those U.S. weapons that could be expected to survive and remain operable after a massive, surprise nuclear first strike by the Soviet Union. The calculations for total force effectiveness also assume that the the United States would withhold 1,000 warheads carried by submarines as a reserve force. Weapons characteristics are shown in Tables 1, 2 and 3 in Chapter II.

Target Growth

The number and type of industrial installations in the Soviet Union that comprise the target base will undoubtedly change in the future. (Military targets are not expected to increase appreciably in numbers because the Soviets are emphasizing qualitative improvements to their forces rather than quantitative growth.) How such changes may affect weapons requirements is uncertain. There will be expansion of current facilities, which might not increase weapons requirements, and construction of new plants, which could. For the purpose of estimating force effectiveness in this paper, enough weapons are included in a reserve force to maintain an effective retaliatory capability, even if there is such a large growth in the number of industrial targets that, by 1990, there would be a 40 percent increase in the number of weapons required to achieve equivalent damage levels.

Weapon Allocation

Allocation of the weapons that may be expected to survive a Soviet first strike requires judging how many weapons will be allocated to Soviet industrial targets, how many to military targets, and how many to silos. There is no satisfactory way to make these judgments because of the very different targets involved. These targets are valued in quite different terms. Industry may be evaluated in dollar terms--for example, its output, its manufacturing value added, or the capital investment in its plant. There are no comparable dollar values for military targets.

One method for solving this problem is to assign values to military targets that would be comparable to the value system used for industry. Each military target would have to be evaluated.

The decision as to whether or not a particular military target is allocated a weapon is effectively made by the value that is arbitrarily assigned to the facility.

An alternative method is to fix the damage to be achieved on one set and use the remaining weapons to maximize damage on the second. This is the system employed in this paper to estimate the capability of current and projected forces. Destruction of 80 percent of the industrial target set appears to be a reasonable objective. Weapon allocation is designed to achieve roughly this damage level in each industrial category (steel mills, refineries, etc.). The remaining weapons are used to maximize damage to military targets.

Other Hedges

To hedge against Soviet civil defense measures, it is assumed that half of the Soviet industrial base is hardened to 30 psi (that is, protection of machinery from building collapse).

DAMAGE EXPECTANCY

The probability of destroying a target as a result of a nuclear strike is termed damage expectancy. A target may not be destroyed because a weapon fails in the launch phase or fails in flight (reliability), fails to travel to the target (penetration--for example, a bomber may be shot down), misses the target (accuracy), or the kill area of the weapon is smaller than that of the target.

Mathematically, $DE = 1 - (1 - R \times Pk)^n$, where

DE = damage expectancy;

R = reliability times probability of successful penetration;

Pk = the kill probability of the weapon against the target;

n = the number of weapons of the same type allocated to the target.

A weapon with a small yield that is allocated to a large-area target would not be expected to destroy the target completely. This will lower the kill probability. For example, a half-mile-radius target complex composed of buildings (hardness represented by a vulnerability number of 14Q7) that is attacked by a 40-kiloton weapon (1,500 ft. CEP) would result in only a 0.80 probability of damage (Pk). A less accurate weapon would produce a still lower Pk. For example, a 40-kiloton weapon with a 3,000 ft. CEP would have a 0.60 Pk against this hypothetical target.

Damage expectancy is used as a guide to the allocation of weapons to targets. Although it computes damage to targets and population casualties, the SNAPPER model does not actually allocate weapons to targets. Such allocations must be provided as input data. To make such allocations requires that relative values be assigned to targets. Then, by applying damage expectancy to these values, one can choose among competing targets. First, one weapon is assigned to each target, starting with the most valuable and proceeding down the list. Eventually, the additional gain from allocating a second weapon to the most valuable target is more than would be obtained by attacking an additional target. For example, if the first target has a value of 1,000 and the weapon Pk is 0.80, then, assuming 100 percent reliability, one bomb would destroy 800 units of target value. 3/ Allocating a second weapon to this target would result in additional value destroyed of 160 units. 4/ Therefore, this second weapon should be allocated to the first target before a target valued at 159 units is attacked. Proceeding in this fashion, a rough allocation of weapons can be made.

The first weapon allocated to a target class achieves the greatest damage because it would be allocated to the most valuable target. The second weapon could be allocated to the next most valuable or to the same target but, in either case, it would result in a smaller increase in damage than the first weapon. As the number of weapons allocated to a target class increases, the amount of damage expected from each additional weapon decreases so that a point is reached where the allocation of additional weapons produces little increase in damage.

3/ $1,000\ [1-(1 - 1 \times .8)] = 800$.

4/ This is computed as the difference in the effect of two weapons ($1,000\ [1-(1 - 1 \times .8)^2]$) and a single weapon ($1,000\ [1-(1 - 1 \times .8)]$).

Poseidon Weapons

An index of damage expected from Poseidon warheads is displayed in Figure B-1 for attacks against the industrial and military target bases (exclusive of ICBM silos) used in this paper. 5/ Weapon reliability is included in the calculations. Allocating 1,200 Poseidon warheads against industry would achieve about 80 percent damage to the target base. Eight Poseidon submarines at sea would have more than 1,200 warheads on board ("surviving submarine" line in Figure B-1). More submarines are needed in the force to maintain eight at sea, however, because of overhaul and repair requirements. Under alert conditions, all submarines not in overhaul would be expected to be at sea so that, out of ten submarines in the force ("generated alert" line), eight would be at sea. If the force were not alerted, only those submarines at sea on normal deployments might survive a Soviet first strike. In this case, fifteen would be required in the force ("day-to-day alert" line) in order to have eight at sea. Therefore, under normal peacetime alert conditions, a force of fifteen Poseidon submarines would be enough to achieve about 80 percent damage to the industrial target base even after a Soviet first strike.

General purpose military targets are usually more resistant to nuclear effects than industrial targets. Most weapon storage sites, for example, are hardened so that a weapon must detonate very close to the target to be effective. Poseidon warheads are not particularly effective against hardened targets. Even if all the Poseidon warheads expected to survive a Soviet surprise attack were allocated to military targets, just over 50 percent of the military target base would be expected to be destroyed (see Figure B-1).

Cruise Missiles

Cruise missiles provide major advantages in nuclear warfare because of their accuracy. Some 900 weapons would be expected to destroy about 80 percent of the industrial target base (see Figure B-2), and they could be carried by 45 surviving B-52s with 20 cruise missiles each. If it is assumed that the bombers must

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5/ Complete destruction of the target base equals 100 on this index.

Figure B-1

Damage from Poseidon Submarines

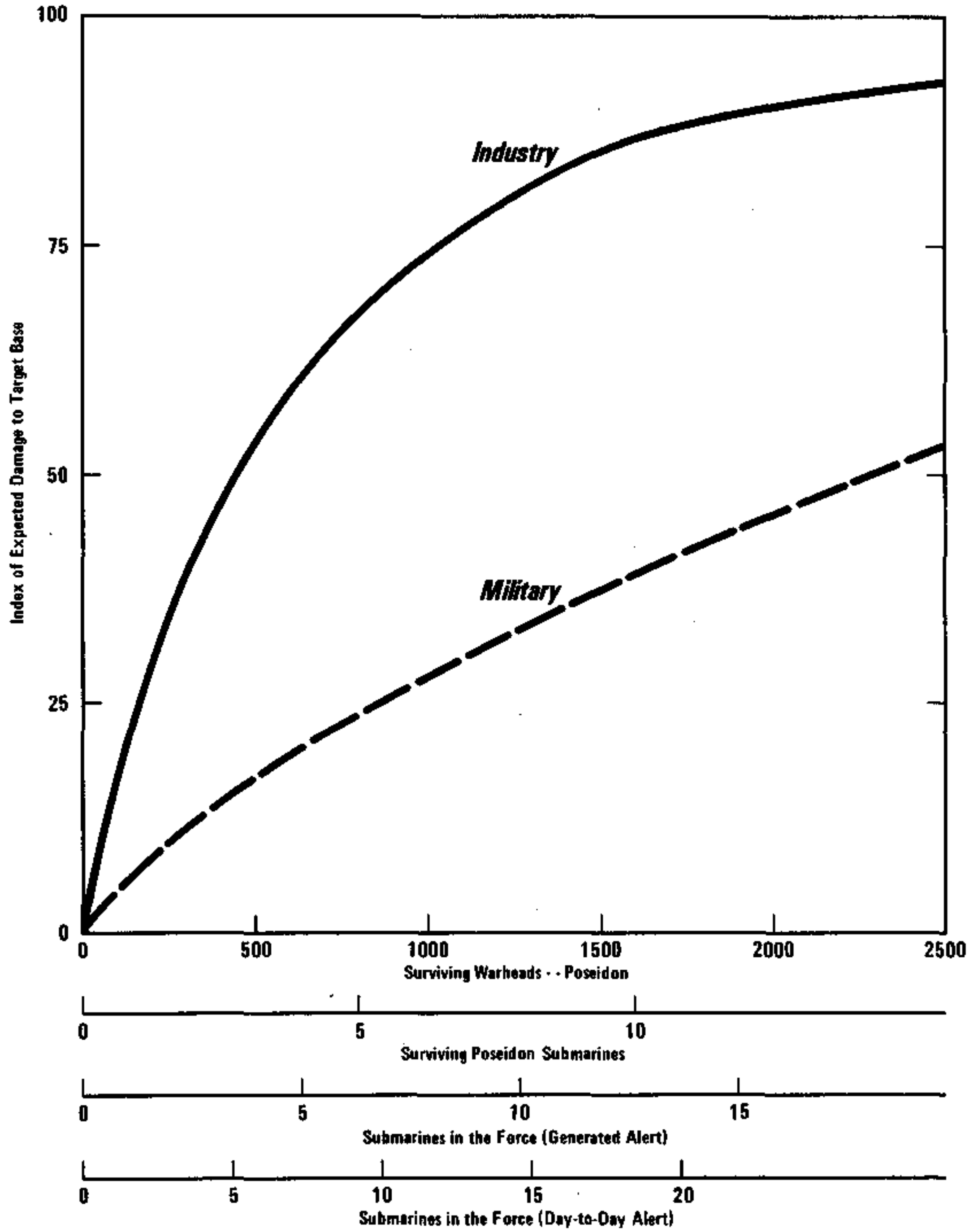
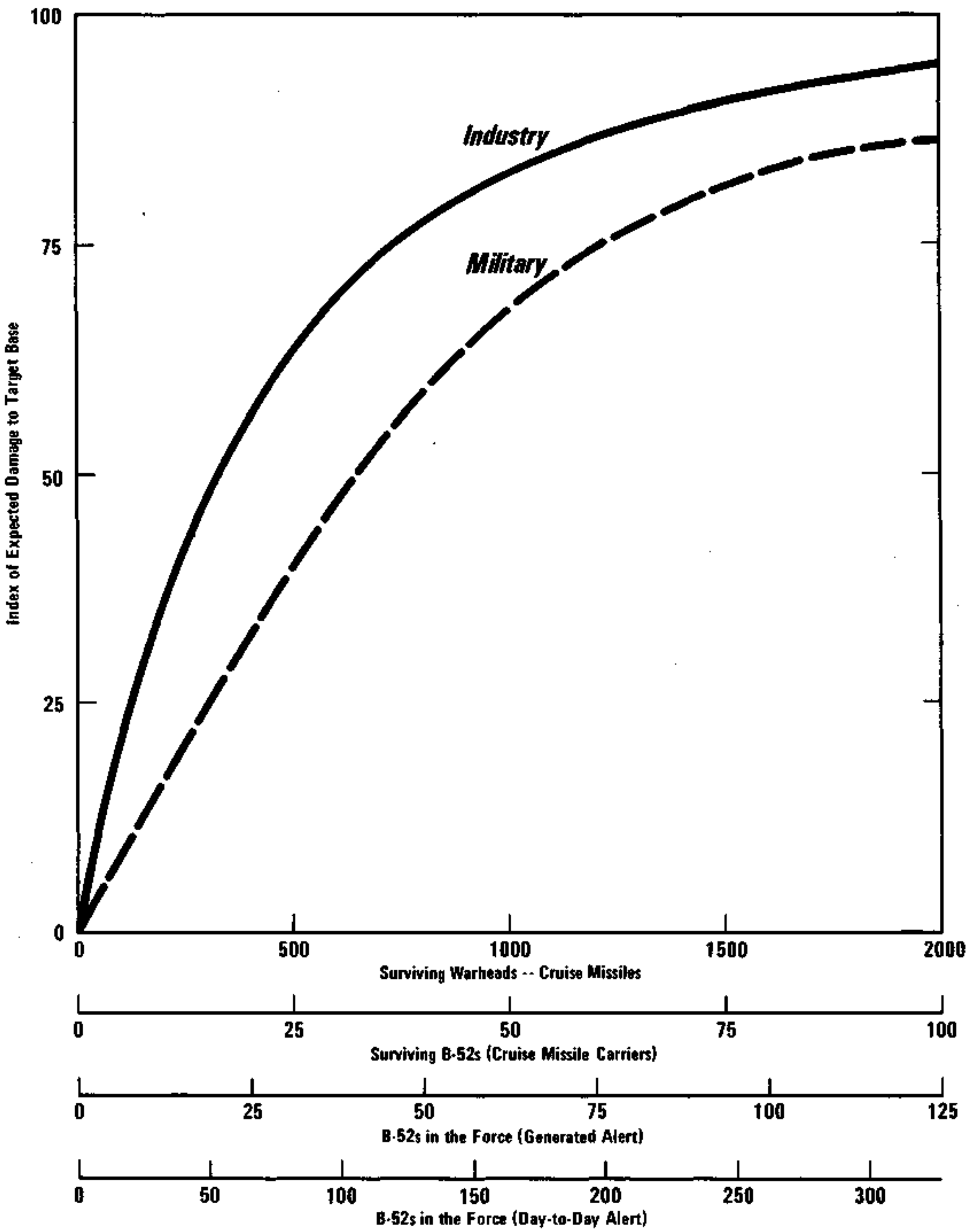


Figure B-2
Damage from B-52s Carrying Cruise Missiles



survive a Soviet first strike, additional aircraft must be in the force in order to insure the survivability of 45 aircraft. The survivability of bombers is dependent on their alert rate. 6/ In a time of crisis, the alert rate may be increased to 80 percent of the force (generated alert). In this case, fewer than 60 B-52 bombers would be expected to destroy 80 percent of the industrial target base. Against military targets, some 650 cruise missiles would be expected to destroy about 50 percent of the military target base. Only 40 bombers would be needed in the force, assuming high alert rates, to assure the delivery of this number of weapons.

Bombs

Figure B-3 displays the damage expected from bombers, armed with four bombs each, for attacks against the industrial and military target bases. 7/ The allocation of about 700 bombs would be expected to destroy about 80 percent of industrial target value. If each bomber carried four bombs, 175 aircraft could deliver this attack. If a period of tension preceded the start of a nuclear conflict and the bomber force was on generated alert, over 200 bombers would have to be in the force to insure that 175 survived. At the peacetime alert rate of 30 percent, nearly 600 bombers would be needed in the force to destroy 80 percent of the industrial target base. Because of their higher yields, bombs are somewhat more effective than cruise missiles against military targets; about 550 bombs would be expected to destroy about 50 percent of the military target base. Clearly, an

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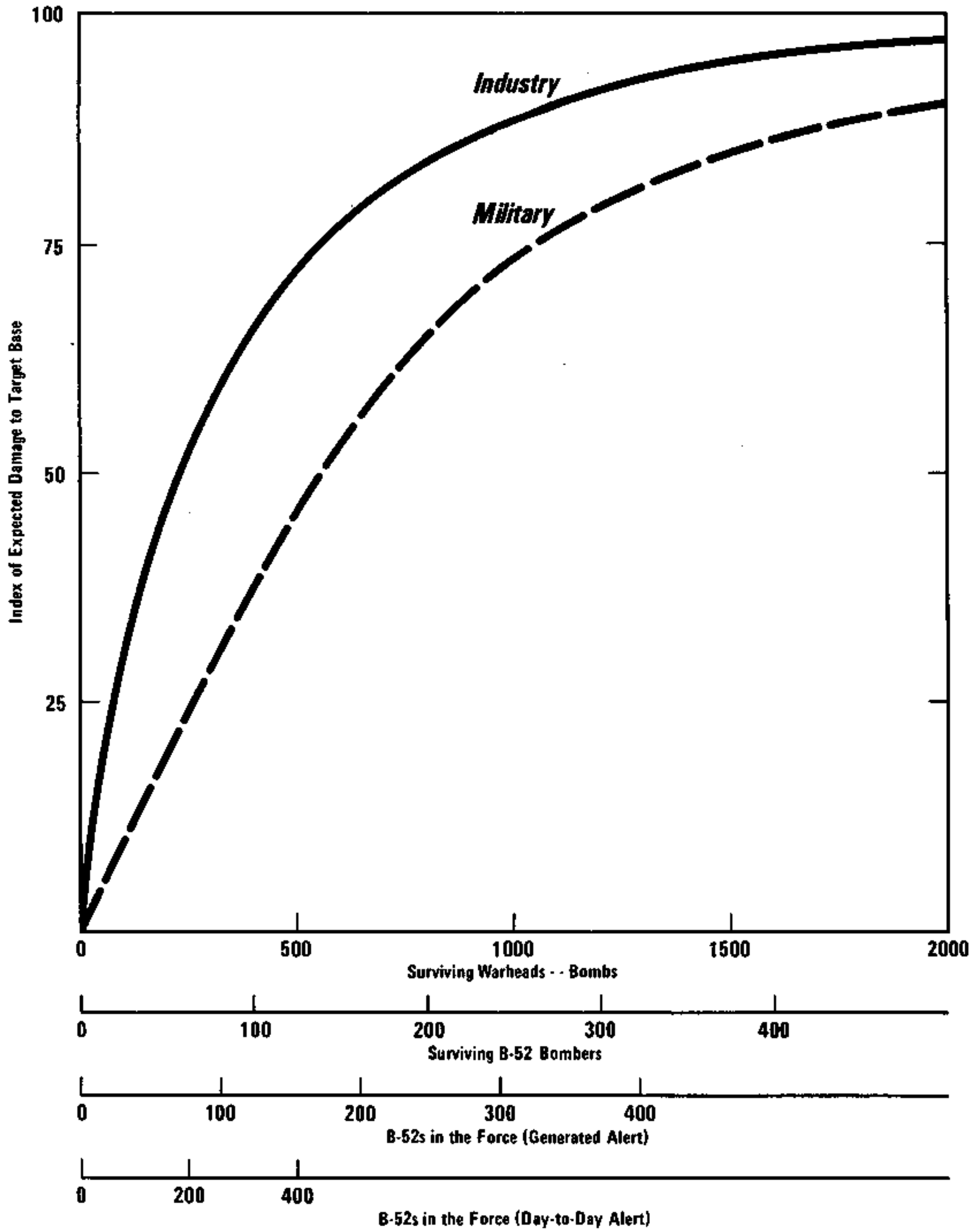
6/ A bomber is on normal peacetime, or day-to-day, alert when the crew is in the alert facility with the aircraft in the normal parking area. Higher alert states may be reached in times of crisis. The crew may be in the aircraft at the end of the runway, the auxiliary power unit may be running, and, at the highest posture, the engines may be running. In peacetime, about 30 percent of the bomber force is on alert. This proportion may increase in a time of tension up to about 80 percent of the force.

7/ B-52G/H bombers also carry SRAMs and would be more effective in terms of damage to industrial targets than the aircraft with bombs only that are shown in Figure B-3.

Figure B-3
Damage from Bombers



optimal weapons allocation would assign Poseidon warheads to industrial targets and larger-yield weapons such as bombs to military targets.

Other Weapons

Minuteman III warheads would be about as effective as cruise missiles against either industrial or military targets. Their slightly smaller yield and lower accuracy is offset by the higher probability of penetration by the Minuteman warhead. The short-range attack missiles (SRAMs) carried by bombers would be nearly as effective as cruise missiles against industrial targets, but their lower accuracy would result in less effectiveness against military targets. Because Trident I warheads have the same accuracy and reliability as Poseidon warheads but a larger yield, they would be more effective than the Poseidon against both industrial and military targets.

Silos

None of the weapons currently in the U.S. inventory is particularly effective against the silos that house land-based missiles. The best current system, Minuteman III with a reported 0.17 megaton warhead and a 700 ft. CEP (see Table 1 in Chapter II), would have a 0.40 probability of kill against improved silos (2,000 psi hardness) with reliability included. This means that 1,400 Minuteman III warheads (out of an inventory of 1,650) would be expected to destroy only 500 Soviet silos. A bomb would be slightly more effective, with a 0.45 kill probability but would take much longer to reach the target than a missile warhead.

Future, more accurate weapon systems such as MX, Trident II, and cruise missiles promise improved counterforce capability. Including reliability and penetration probability, an MX warhead would have a 0.82 kill probability; a cruise missile, about 0.65; and Trident II, about 0.55. There are many arguments both for and against the deployment of a counterforce capability. 8/ Until these more accurate systems are deployed, however, there appears to be little reason to allocate warheads against Soviet silos.

8/ For a detailed discussion of counterforce capability, see Congressional Budget Office, Counterforce Issues for the U.S. Strategic Nuclear Forces, Background Paper (January 1978).

Alert Assumptions

An important planning assumption for force sizing is that U.S. forces must be capable of retaliating after absorbing a massive Soviet first strike when U.S. forces are in a normal peacetime alert posture. As indicated by Figure B-1, if one were to assume that nuclear war would start only after an increase in tension, then a force of ten Poseidon submarines would be sufficient for destroying much of Soviet industry. The use of the surprise attack scenario for force planning, however, would increase the force requirement by 50 percent. The alert rate is even more important for bombers (see Figure B-3) because nearly three times as many are required to be in the force for a surprise attack scenario compared to the generated alert case.

Antiballistic Missile (ABM) System: A system to counter strategic ballistic missiles or their elements in flight trajectory.

Antisubmarine Warfare (ASW): Measures to detect, locate, track, and destroy submarines currently primarily dependent upon acoustic sensors.

B-52: The mainstay of the U.S. strategic bomber force since the 1950s. About 250 late model G and H aircraft and 75 rewinged D bombers are expected to remain in the inventory until the early 1990s. Many of these will be equipped with cruise missiles in the early 1980s, while others will continue to carry gravity bombs and short-range attack missiles.

Ballistic Missile: Any missile which does not rely upon aerodynamic surfaces to produce lift and consequently follows a ballistic trajectory (that is, one resulting when the body is acted upon only by gravity and aerodynamic drag) when thrust is terminated.

Circular Error Probable (CEP): A measure of the delivery accuracy of a weapon system used as a factor in determining probable damage to targets. It is the radius of a circle around the target at which a missile is aimed within which the warhead has a 0.5 probability of falling.

Counterforce Strike: An attack aimed at an adversary's military capability, especially his strategic nuclear military capability.

Cruise Missile: A guided missile which uses aerodynamic lift to offset gravity and propulsion to counteract drag. The major portion of a cruise missile's flight path remains within the earth's atmosphere.

1/ Definitions are from SALT Lexicon, U.S. Arms Control and Disarmament Agency, 1974; and from Projected Strategic Offensive Weapons Inventories of the U.S. and USSR, Congressional Research Service, March 24, 1977.

Cruise Missile Carrier (CMC): An aircraft capable of delivering cruise missiles to within range of their targets. Current plans call for the use of B-52 bombers in this role. In the mid-1980s, wide-bodied commerical aircraft may be procured to supplement, and eventually replace, the B-52 force.

Electronic Countermeasures (ECM): Measures used by bombers or other aircraft to negate the effectiveness of enemy air defense radars, surface-to-air missiles, and interceptor aircraft.

Equivalent Megatons (EMT): A commonly used measure of the urban area destructive power of a nuclear weapon that accounts for the fact that area destructive power does not increase proportionately with increases in yield. It is expressed by the relationship EMT = N multiplied by Y to the 2/3 power, where N is the number of weapons of yield Y.

FB-111: Medium bombers procured in small numbers in the late 1960s to supplement the B-52 force. Although capable of supersonic low-level flight, the aircraft's small range and payload limits its effectiveness. Modified stretched FB-111H bombers may be added to the bomber force in the 1980s.

First Strike (Nuclear): The launching of an initial strategic nuclear attack before the opponent has used any strategic weapons himself.

Generated Alert: A condition when forces are placed in a high state of readiness, with the vast majority of the bomber force on ground alert ready for rapid take-off and the vast majority of the submarine force at sea.

Hardness: The amount of protection afforded by structural shielding against blast, heat, and radiation effects of nuclear explosions, usually measured in pounds per square inch (psi).

Intercontinental Ballistic Missile (ICBM): A land-based, rocket-propelled vehicle capable of delivering a warhead to intercontinental ranges (ranges in excess of about 3,000 nautical miles).

Kiloton (KT): The yield of a nuclear weapon equivalent to 1,000 tons of TNT.

Megaton (MT): The yield of a nuclear weapon equivalent to 1,000,000 tons of TNT.

Minuteman: The mainstay of the U.S. ICBM force since the early 1960s. At the present time, the United States maintains a force of 450 single-warhead Minuteman II missiles and 550 three-warhead Minuteman III missiles.

MK-12A: A higher yield, more accurate warhead designed to replace the MK-12 warhead presently deployed on Minuteman III missiles. MK-12A warheads may also be deployed on MX ICBMs and Trident II SLBMs.

Multiple Independently Targetable Reentry Vehicle (MIRV): Two or more reentry vehicles carried by a single missile and capable of being independently targeted.

MX: A more powerful, more accurate ICBM now in the research and development stage that may supplement the Minuteman force in the mid-1980s. Current plans call for mobile basing for MX missiles. Missiles would be moved either within underground protective trenches or among protective above-ground shelters.

Payload: The weapon and/or cargo capacity of any aircraft or missile system, expressed variously in pounds, in number of weapons, and in terms of missile warhead yields.

Polaris: U.S. submarines that carry the first generation of submarine-launched Polaris missiles. Each submarine can carry 16 missiles. The Polaris is expected to begin leaving the force in the early 1980s.

Poseidon: U.S. submarines that carry the first generation of multiple-warhead, submarine-launched Poseidon missiles. Each submarine can carry 16 missiles. The thousands of warheads carried by these 31 submarines comprise the most survivable element of the U.S. nuclear retaliatory capability. These submarines are expected to be replaced by Trident submarines during the late 1980s and early 1990s.

Reentry Vehicle (RV): That portion of a ballistic missile designed to carry a nuclear warhead and to reenter the earth's atmosphere in the terminal portion of the missile trajectory.

Second Strike: A term usually used to refer to a retaliatory attack in response to a first strike.

Silo: Underground facilities for a hard-site ballistic missile and/or crew, designed to provide prelaunch protection against nuclear effects.

Short-Range Attack Missile (SRAM): An air-to-surface missile carried by U.S. FB-111 and B-52 bombers.

SS-18: A large Soviet surface-to-surface missile. The largest ICBM in the world, the SS-18 can carry eight to ten megaton-range warheads. Now being deployed, about 300 SS-18s may eventually replace older, single-warhead SS-9s. Smaller SS-19s and SS-17s, both multiple-warhead missiles, are currently replacing older, single-warhead SS-11s.

SSBN: Nuclear-powered ballistic missile submarine.

Strategic Stability: Strategic stability encompasses both crisis stability and arms stability, and refers to a relationship in which neither side has an incentive to initiate the use of strategic nuclear forces in a crisis or perceives the necessity to undertake major new arms programs to avoid being placed at a strategic disadvantage.

Submarine-Launched Ballistic Missile (SLBM): A ballistic missile carried in and launched from a submarine.

Surface-to-Air Missile (SAM): A surface-launched missile employed to counter airborne threats.

Throw-Weight: Ballistic missile throw-weight is the maximum useful weight which has been flight tested on the boost stages of the missile. The useful weight includes weight of the reentry vehicles, penetration aids, dispensing and release mechanisms, guidance devices, reentry shrouds, covers, buses, and propulsion devices with their propellants (but not the final stages) that are present at the end of the boost phase.

Trident: U.S. submarines now under construction that are expected to replace the Polaris/Poseidon fleet. Each submarine will be able to carry 24 Trident I or Trident II missiles. The Trident II missile, now entering research and development, will provide an option to improve the accuracy and increase the destructive power of the sea-based nuclear force in the mid-to-late 1980s.

Warheads: That part of a missile, projectile, or torpedo that contains the explosive intended to inflict damage.

Yield: The force of a nuclear explosion expressed in terms of the number of tons of TNT that would have to be exploded to produce the same energy.